Using CAI with Fidelity: Impacts on Literacy Skills of Kindergarten Students Across Demographics

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Abstract: This study investigated the impact of a computer-adaptive reading program, Waterford Early Learning (WEL), in an elementary school in Indiana. The study investigated how educational technology, specifically computer-assisted instruction (CAI), would impact the literacy scores of kindergarten students when paired with traditional instruction: Students with active special education status and no special education status used the program during an educational year when they acquired vital literacy skills. Experimental students across demographics, including lunch status and special education status, outperformed their control counterparts on all strands. From these findings, researchers can tentatively conclude that students with active special education status can potentially greatly benefit from CAI in the classroom, especially during a year when so many critical literacy skills are practiced and mastered. Furthermore, students who used WEL with fidelity significantly outperformed their control counterparts across all reading strands. Findings indicate that CAI technology can positively impact students' scores in a single school year.

Introduction

Computer-assisted instruction (CAI) refers to an instructional approach in which technology is comprehensively blended into how lessons are designed and educational material is presented to students. CAI has been shown to be an effective means of improving the academic skills of young students across most backgrounds. A study using a large sample of English Learners and non-English Learners in kindergarten found that after one year of using a CAI intervention, literacy scores of all students improved significantly (Kazakoff, Macaruso, & Hook, 2018). Similar research following low socio-economic status second grade students found the reading skills of Title I students improved significantly after using a CAI intervention (Wilkes, Macaruso, Kazakoff, & Albert, 2016). CAI can also foster engagement with a lesson using interactive and entertaining media. When 26 fifth grade students were taught an introductory science unit using a web-based multimedia enabled approach, they showed both greater understanding of and more enthusiasm for the material than students who were taught through traditional teacher-directed instruction (Ercan, Bilen, & Ural, 2016). In general, research has indicated that CAI has a positive effect on learning outcomes of young students; a recent meta-analysis examining the efficacy of CAI for elementary school students across 122 peer-reviewed studies found that CAI significantly improved learning outcomes with a medium effect size (Chauhan, 2017).

Research into whether CAI can have a positive impact on the skills of students with special needs has taken place for about as long as CAI has been explored as a general phenomenon. Around the same time that the principles of CAI were being codified (Bangert-Drowns, Kulik, & Kulik, 1985), research explored the potential benefits of what were at the time emerging technologies on the learning outcomes of vulnerable students (Panyan, 1984). Initial research at that time suggested that through reinforcing specific lessons as they were happening, technology had the potential to foster engagement with material and to address learning difficulties.

Most available research looking into the efficacy of technology for the learning outcomes of students with special needs has taken the form of case studies and small sample size intervention trials. In one recent case study,

three elementary school aged boys in a special education program demonstrated improved comprehension when using a shared story reading exercise with embedded prompting delivered through touch screens (Alison, Root, Browder, & Wood, 2017). Embedded prompts highlighted words and sections of the story that in traditional, teacher-directed lessons would have to be singled out by teachers or aides, providing students with more in-depth text analysis assistance. Additionally, the authors reported that the benefit to comprehension from the technology-enabled story exercise was later generalized to items without the embedded prompting. Similar results were found in an earlier study where a computer-delivered instructional program incorporating graphical organizers was employed to teach three students with mild to moderate intellectual disabilities to follow a discrete series of instructions – in this case, to learn a series of recipes (Douglas, Ayres, Langone, & Bramlett, 2011). With the benefit of the interface, students had an easier time learning the material presented, and the gains made while using technology were later generalized when learning novel lessons without the support of CAI. In a separate study, three students on the autism spectrum receiving a touch screen delivered intervention showed significant improvement on measures of vocabulary (Ganz, Boles, Goodwyn, & Flores, 2014). Research has also indicated that CAI may be of particular benefit to the most vulnerable students; in a case study of five elementary school aged students with severe intellectual disabilities, students using portable technology demonstrated significant improvement on measures of literacy skills (Spooner et al., 2015). Case studies have also shown that the benefits of CAI are not strictly isolated to learning outcomes: In a study that followed three students with developmental disabilities who received a CAI intervention, two of the three students demonstrated not only increased engagement with the lesson material but decreased behavioral difficulties (LeJeune, 2019). These case studies do support the efficacy of CAI for students with special needs, but the small sample sizes limit confident inferences.

Meta-analyses and reviews which synthesize findings across multiple studies are more rigorous and conclusive than case studies. While not all attempts at aggregation reach the same conclusions, this approach can provide a broader perspective than individual studies taken in isolation. A general meta-analysis looking into multiple different literacy interventions for students with special needs in elementary school across 24 studies found that, on the whole, literacy interventions tended to have large effects on comprehension (Wanzek, Wexler, Vaughn, & Ciullo, 2010). However, a concurrent meta-analysis looking specifically into whether technology-enabled interventions could benefit students on the autism spectrum found that results were too varied and inconsistent to conclude that the interventions had positive effects on student level learning outcomes (Ramdoss et al., 2011). More recently, researchers who synthesized 13 adequate-to-high quality studies involving 94 students on the autism spectrum argued that CAI interventions not only teach academic skills and improve learning outcomes but, as a category, meet the standard of an evidence-based practice (Root et al., 2017). Given the shifting consensus on the efficacy of educational technology for students with developmental disabilities, more research is still needed.

A study with a comparatively large sample of special needs students recently called into question the use of technology in the classroom for this population (Brunero, Venerosi, Chiarotti, & Arduino, 2019). When 63 students on the autism spectrum received either traditional paper-supported or technology-enabled lessons, the students who received supplemental technology communicated and cooperated less and needed more additional help than students receiving traditional instruction. Given these results, taken alongside the general lack of consensus in the literature, it is understandable if parents and educators are hesitant for students with special needs to use CAI (Parsons, Yuill, Brosnan, & Good, 2015). It is for this very reason that further experimental research is required to determine if a given intervention can improve learning outcomes of the most vulnerable students.

This study explored the benefits of a computer-adaptive reading program, Waterford Early Learning (WEL), on the literacy test scores of students. The study tested two hypotheses: (1) Students who had higher usage of WEL would score higher on a standardized assessment of literacy skills than students who had lower usage at the end of their kindergarten school year. (2) Students with active special education status who had higher usage of WEL would score higher on a standardized assessment of literacy skills than students with active special education status who had lower usage at the end of their kindergarten school year.

Methods

Participants

This study consisted of kindergarten students (N = 142) enrolled in a town: distant public school district in Indiana during the 2017-2018 school year. Roughly 15% of participating students had active special education status and roughly 49% qualified for free/reduced lunch. The experimental group (n = 101) included students who used WEL for more than 1,000 minutes during kindergarten. The control group (n = 41) included students who used WEL for less than 300 minutes during kindergarten.

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.

Northwest Evaluation Association (NWEA) Measures of Academic Progress (MAP)

The NWEA MAP is a valid assessment intended to measure individual growth and mastery of students in kindergarten through twelfth grade on a range of skills. Results are scored on a standardized Rasch Unit (RIT) scale. The strands considered relevant to kindergarten students in this study are Reading RIT Score, Reading Foundations, Reading Literature and Nonfiction, Reading Vocabulary, and Writing.

Procedure

Students were expected to use WEL for fifteen minutes per day, five days per week. Usage was tracked within the program and monitored weekly, and total minutes of usage for the school year per student were calculated. The NWEA MAP assessment was administered to all students at the beginning and end of the school year.

Findings

Group Differences Using Analysis of Covariance (ANCOVA)

ANCOVAs were conducted to examine group differences in end of year NWEA MAP reading scores between the experimental and control groups while covarying for beginning of year scores (Fig. 1). Analysis of end of year scores, covarying for beginning of year scores, revealed significant differences between groups due to higher end of year scores made by experimental students than by control students for: Reading RIT scores, $F(1, 139) = 22.94$, $p < .01$; Reading Foundations scores, $F(1, 139) = 22.41$, $p < .01$; Reading Literature and Nonfiction scores, $F(1, 139) = 18.11$, $p < .01$; Reading Vocabulary scores, $F(1, 139) = 15.00$, $p < .01$; and Writing scores, $F(1, 139) = 16.54$, $p < .01$. Effect sizes ranged from medium ($d = 0.63$, Reading Vocabulary) to large ($d = 0.80$, Reading Foundations) (Tab. 1).

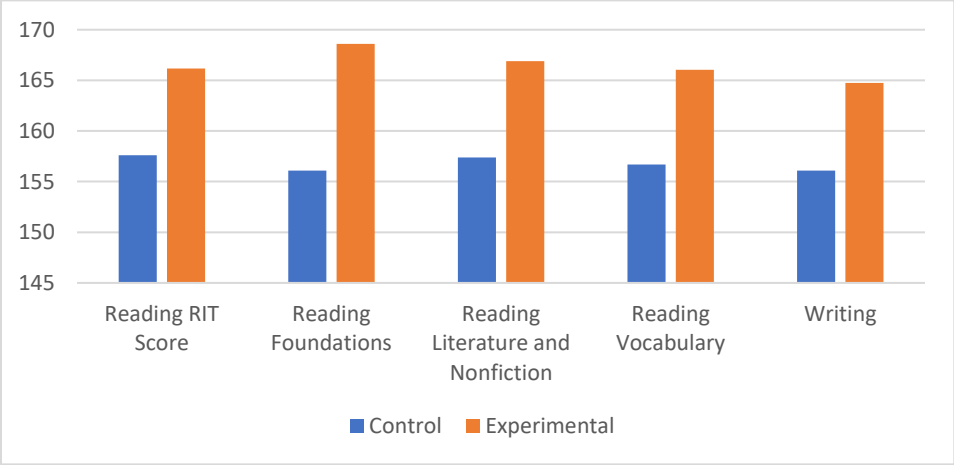

Figure 1: Kindergarten NWEA MAP Reading End of Year Scores Covarying for Beginning of Year Scores by Strand

Strand	Effect Size (*d*)
Reading RIT Score	0.68
Reading Foundations	0.80
Reading Literature and Nonfiction	0.69
Reading Vocabulary	0.63
Writing	0.65

Table 1: Effect Sizes of Kindergarten NWEA MAP Reading End of Year Scores

Group Differences by Demographics Using ANCOVAs

Further analysis was conducted to examine the impact of demographics on end of year scores, while covarying for beginning of year scores (Figs. 2-3).

Special Education Status

There was no significant interaction between the effects of special education status and WEL for any strand. For Reading RIT Score, Reading Vocabulary, and Writing, simple effects analysis showed that for students with active special education status and no special education status, students in the experimental group significantly outperformed students in the control group. For Reading Foundations and Reading Literature and Nonfiction, simple effects analysis showed that for students with no special education status, students in the experimental group significantly outperformed students in the control group; for students with active special education status, students' scores in the experimental group were higher than in the control group, but the difference was not significant.

Lunch Status

There was a significant interaction between the effects of lunch status and WEL on Writing end of year scores while covarying for beginning of year scores, $F(1, 137) = 4.09$, $p < .05$, and no significant interaction was found for any other strand. Simple effects analysis showed that for students with paid lunch status, across strands, students in the experimental group significantly outperformed students in the control group. For students with free/reduced lunch status, across strands except Writing, students in the experimental group significantly outperformed students in the control group. For Writing, scores of students with free/reduced lunch status in the experimental group were higher than in the control group, but the difference was not significant.

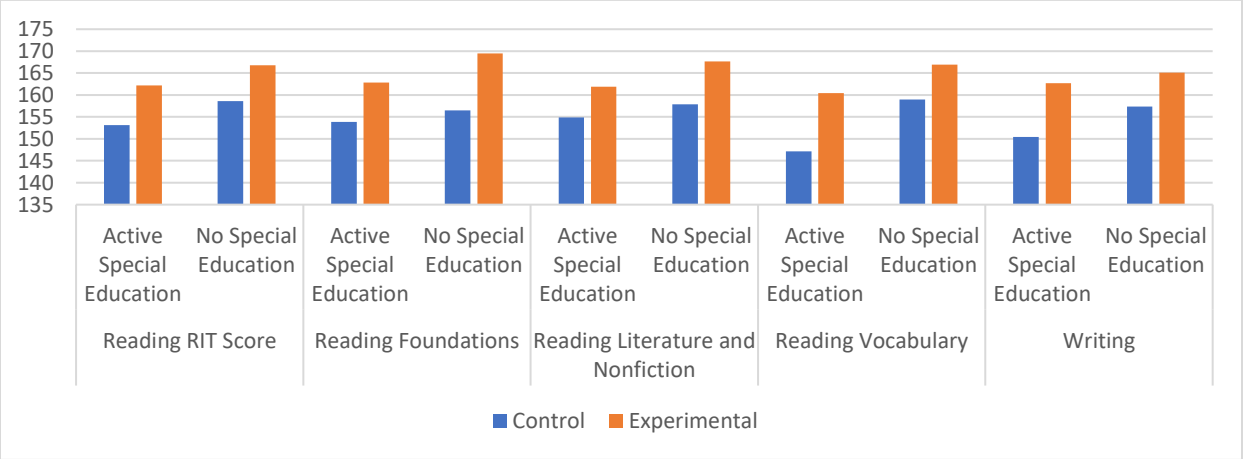

Figure 2: Kindergarten NWEA MAP Reading End of Year Scores Covarying for Beginning of Year Scores by Special Education Status

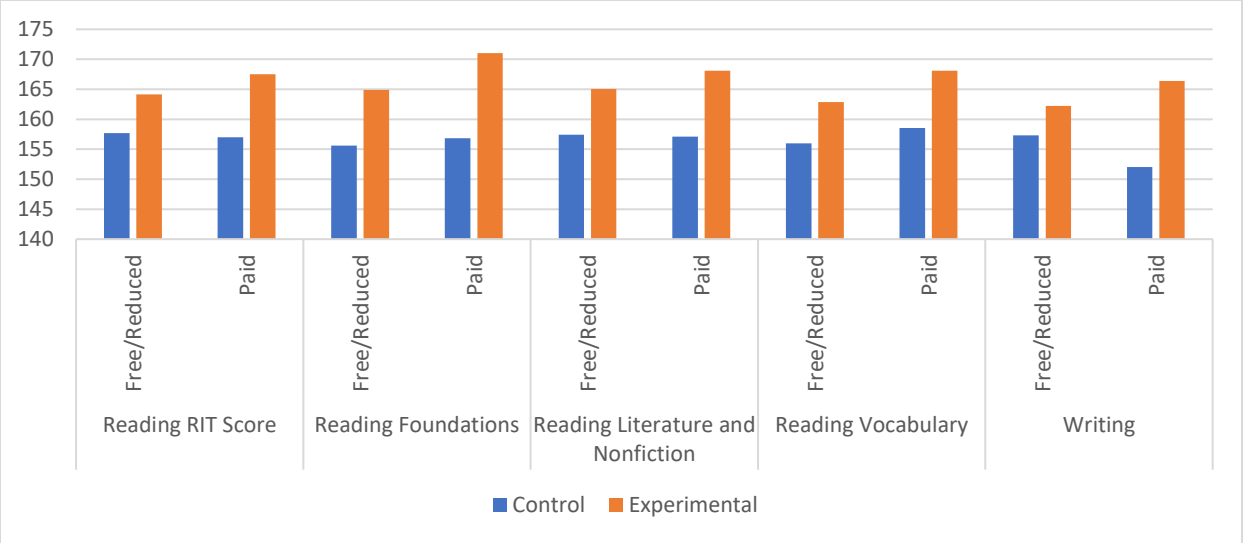

Figure 3: Kindergarten NWEA MAP Reading End of Year Scores Covarying for Beginning of Year Scores by Lunch Status

Conclusions

In this study, standardized test scores of students who used WEL, a computer-adaptive reading program, were assessed at the beginning and end of the school year. The findings of this study provide insight into a critical window in the educational process when kindergarten students learn essential literacy skills.

Both hypotheses of the current study were supported. When end of kindergarten scores were assessed while covarying for beginning of kindergarten scores, students who used WEL for at least 1,000 minutes significantly outperformed students who used the program for less than 300 minutes on all five strands of the NWEA MAP, including Reading RIT Score, Reading Foundations, Reading Literature and Nonfiction, Reading Vocabulary, and Writing. Standardized test scores of students who used WEL with fidelity were higher than scores of control students. Additionally, effect sizes were assessed, and the medium to large effect sizes indicated that higher use of CAI lead to substantively higher end of year scores once beginning of year scores were taken into account.

For both students with active special education status and students with no special education status, students with higher usage of WEL outperformed their control counterparts who had less usage across all strands. Additionally, test scores of students with active special education status with higher usage of WEL were significantly higher than their control counterparts on three out of the five NWEA MAP strands, including Reading RIT Score, Reading Vocabulary, and Writing. These findings indicate that CAI can improve the academic performances of students with active special education status. Similar results were also found when test scores were assessed across lunch status. Once beginning of year scores were controlled for, students with free/reduced lunch status and students with paid lunch status with more usage of WEL significantly outperformed their control counterparts on all NWEA MAP strands with the exception of Writing. Computer-adaptive reading programs have the potential to assist young learners across demographics with acquiring the necessary literacy skills to succeed in school.

This study took place within a single school district, which may limit generalizability of its findings. This study also lacked longitudinal data and as a result cannot address whether gains made while using WEL would have been sustained.

References

Alison, C., Root, J. R., Browder, D. M., & Wood, L. (2017). Technology-based shared story reading for students with autism who are English-language learners. *Journal of Special Education Technology, 32*(2), 91-101.

Bangert-Drowns, R. L., Kulik, J. A., & Kulik, C. L. C. (1985). Effectiveness of computer-based education in secondary schools. *Journal of Computer-Based Instruction, 12*(3), 59-68.

Brunero, F., Venerosi, A., Chiarotti, F., & Arduino, G. M. (2019). Are touch screen technologies more effective than traditional educational methods in children with autism spectrum disorders? A pilot study. *Annali dell'Istituto Superiore di Sanità, 55*(2), 151-160.

Chauhan, S. (2017). A meta-analysis of the impact of technology on learning effectiveness of elementary students. *Computers & Education, 105*, 14-30.

Douglas, K. H., Ayres, K. M., Langone, J., & Bramlett, V. B. (2011). The effectiveness of electronic text and pictorial graphic organizers to improve comprehension related to functional skills. *Journal of Special Education Technology, 26*(1), 43-56.

Ercan, O., Bilen, K., & Ural, E. (2016). 'Earth, Sun and Moon': Computer assisted instruction in secondary school science - achievement and attitudes. *Issues in Educational Research, 26*(2), 206-224.

Ganz, J. B., Boles, M. B., Goodwyn, F. D., & Flores, M. M. (2014). Efficacy of handheld electronic visual supports to enhance vocabulary in children with ASD. *Focus on Autism and Other Developmental Disabilities, 29*(1), 3-12.

Kazakoff, E. R., Macaruso, P., & Hook, P. (2018). Efficacy of a blended learning approach to elementary school reading instruction for students who are English Learners. *Educational Technology Research and Development, 66*(2), 429-449.

LeJeune, L. M. (2019). Improving behavior of students with intellectual and developmental disabilities with computer-assisted literacy instruction: an experimental comparison [Unpublished doctoral dissertation]. Vanderbilt University.

Panyan, M. V. (1984). Computer technology for autistic students. *Journal of Autism and Developmental Disorders, 14*(4), 375-382.

Parsons, S., Yuill, N., Brosnan, M., & Good, J. (2015). Innovative technologies for autism: Critical reflections on digital bubbles. *Journal of Assistive Technologies, 9*(2), 116-121.

Ramdoss, S., Mulloy, A., Lang, R., O'Reilly, M., Sigafoos, J., Lancioni, G., ... & El Zein, F. (2011). Use of computer-based interventions to improve literacy skills in students with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders, 5*(4), 1306-1318.

Root, J. R., Stevenson, B. S., Davis, L. L., Geddes-Hall, J., & Test, D. W. (2017). Establishing computer-assisted instruction to teach academics to students with autism as an evidence-based practice. *Journal of Autism and Developmental Disorders, 47*(2), 275-284.

Spooner, F., Kemp-Inman, A., Ahlgrim-Delzell, L., Wood, L., & Ley Davis, L. (2015). Generalization of literacy skills through portable technology for students with severe disabilities. *Research and Practice for Persons with Severe Disabilities, 40*(1), 52-70.

Wanzek, J., Wexler, J., Vaughn, S., & Ciullo, S. (2010). Reading interventions for struggling readers in the upper elementary grades: A synthesis of 20 years of research. *Reading and Writing, 23*(8), 889-912.

Wilkes, S., Macaruso, P., Kazakoff, E., & Albert, J. (2016, June). Exploration of a Blended Learning Approach to Reading Instruction in Second Grade. *EdMedia+ Innovate Learnin*g, *2016*, Association for the Advancement of Computing in Education, Vancouver, Canada. 797-802.