Effects of Long-Term and Early Use of CAI on Students' Literacy Skills

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Abstract: This study investigated the long-term and early effects of computer-assisted instruction (CAI) on students' literacy skills. Elementary school students in a Maryland school district were given access to CAI as a supplemental reading curriculum for up to three years. At the end of second grade, literacy scores of students who used CAI for two or three years, in kindergarten, first grade, or second grade, were compared to scores of students who did not use the software. Students who used the CAI software had significantly higher scores than those who did not. Additionally, students who used the software for three years scored higher than those who used the software for two years, demonstrating a dosage effect of CAI.

Introduction

Long-term academic success is the primary goal when instructing young learners: Developing early literacy skills at a young age can make a meaningful impact on lifelong academic achievement and adult literacy (Schoon, Parsons, Rush, & Law, 2010). Results from a recent longitudinal meta-analysis indicated that beginning of year kindergarten science scores predicted science achievement in first grade, which in turn predicted science achievement in third grade and eighth grade (Morgan, Farkas, Hillemeier, & Maczuga, 2016). This demonstrates that strong early intervention is necessary to set up students for academic success, as the strongest indicator of gaps in science scores were general knowledge gaps of students entering kindergarten. Similarly, in a longitudinal study investigating the impact of traditional mathematics curriculum, students with low math scores at the beginning of kindergarten had significantly lower math scores than students with high math scores at the beginning of kindergarten and at the end of first grade (Navarro et al., 2012). These findings indicate that early intervention is key to assisting low-achieving students entering kindergarten so that they can keep pace academically with their peers.

Starting educational intervention early may not be enough to have a lasting effect; a meta-analysis of studies looking at long-term effects of early literacy interventions found that positive impacts in academic ability decreased over time (Suggate, 2016). Additionally, a German longitudinal study found that EL students who began learning a foreign language later in elementary school had significantly higher foreign language assessment scores than students who began learning foreign language earlier in elementary school, indicating that early intervention may not be as important as other studies suggest (Jaekel, Schurig, Florian, & Ritter, 2017). However, research shows that a more individualized approach to intervention could account for lasting effects. A study investigating individualized literacy instruction of students over three years, during first, second, and third grade, found that those who received individualized reading instruction throughout all three grades demonstrated higher reading capabilities by the end of third grade (Connor et al., 2013). Students who received a year of individualized reading treatment in second or third grade were tested again at ages nineteen through twenty-two: After more than one decade since the reading intervention, students who received the reading intervention in elementary school outperformed their control counterparts on all literacy strands as adults, with moderate to small effect sizes (Blachman et al., 2014). This demonstrates that when early intervention is individualized it can have a lasting effect on a student's ability. One avenue for providing more individualized instruction is through technology.

As technology becomes more ubiquitous in classrooms, it is worthwhile to examine the impact technology can have on learning outcomes, especially for young students. While it will not replace teachers, current technology

such as e-books and educational software can be widely beneficial as a supplement to teaching (Belo, McKenney, Voogt, & Bradley, 2016; Connor, Goldman, & Fishman, 2014). One study found that providing iPads in preschool and elementary school classrooms increased the level of engagement and enthusiasm for learning in early readers (Flewitt, Messer, & Kucirkova, 2014). Students as young as prekindergarten who used e-books have demonstrated significantly higher emergent literacy skills than students who used traditional print books (Ihmeideh, 2014). A meta-analysis of studies reviewing the effectiveness of e-books found that overall comprehension outcomes were improved when compared to print books (Zucker, Moody, & McKenna, 2009). However, a qualitative study investigated the impact of computer use on GPAs of middle school students and found that the use of poor quality technology in schools had a negative impact on students' GPAs (Lei & Zhao, 2007). These findings indicate that schools need to implement high-quality educational software to see a positive impact.

While it can be beneficial to augment traditional teaching tools such as books, technology can also be used to provide students with new methods of individualized learning. Computer-assisted instruction (CAI) is the presentation of educational material and media in an individually-tailored and interactive way. Unlike traditional large group instruction, CAI allows students to learn at an individual pace by automatically presenting them with content that is appropriate for their level of learning, and providing meaningful, immediate feedback on learning objectives (Jethro, Grace, & Thomas, 2012; Stetter & Hughes, 2010). There is strong potential for CAI to provide high quality, individual instruction, however more research is needed to determine the impact of CAI on literacy skills beyond its immediate use.

Technology can be effective in supplementing traditional reading instruction, though the amount students benefit can be strongly influenced by the level of implementation. Urban preschool students whose curriculum was supplemented with software in a randomized controlled trial had no significant difference in literacy gains when compared to their control counterparts, though students who used the software with higher fidelity did score significantly higher than students who used the software with lower fidelity on letter-name knowledge and beginning sounds (Davidson, Fields, & Yang, 2009). This importance of fidelity extends to CAI, as elementary school students who used CAI more throughout the school year outperformed students who used CAI less in both literacy (Shamir, Feehan, & Yoder, 2017b) and math (Shamir, Feehan, & Yoder, 2017a).

The current study compares long-term learning outcomes of elementary school students who had access to a CAI program for varying amounts of time, as well as students who only received traditional classroom instruction. This study will test the following hypothesis: (1) If use of CAI has an overall effect on literacy scores, then students who used CAI over multiple school years will have higher literacy assessment scores than students who did not use CAI. (2) If use of CAI has a long-term effect on literacy scores, then students who used CAI will have higher literacy assessment scores than students who did not use CAI when assessed a year after use of CAI had stopped. (3) If early use of CAI has an effect on literacy scores, then students who used CAI in kindergarten through second grade will have higher literacy assessment scores than students who used CAI in first and second grade only.

Methods

Participants

This study consisted of second grade students (N = 2,955) enrolled in a public school district in Maryland during the 2017-2018 school year.

The three years of usage experimental condition (n = 2,067) included students who used Waterford Early Learning (WEL) for more than 100 minutes during kindergarten (2015-2016), first grade (2016-2017), and second grade (2017-2018). These students form the experimental condition when assessing overall and early effects.

The two years of usage experimental condition (n = 136) included students who used WEL for more than 100 minutes during kindergarten (2015-2016) and first grade (2016-2017) only. These students form the experimental condition when assessing long-term effects.

The no usage control condition (n = 75) included students who used WEL for less than 100 minutes during all three school years. These students form the control condition when assessing overall and long-term effects.

The two years of usage control condition (n = 677) included students who used WEL for more than 100 minutes during first grade (2016-2017) and second grade (2017-2018) only. These students form the control condition when assessing early effects.

Materials

Waterford Early Learning (WEL)

Waterford Early Learning is a computer-assisted instruction program that teaches pre-reading and reading concepts. The adaptive program is intended for pre-kindergarten through second grade students and provides instruction to students via interactive songs, stories, and activities that ensure mastery of each individual early literacy skill.

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

The MAP is a valid assessment intended to measure individual growth and mastery for students in kindergarten through twelfth grade on a range of skills. The skills considered relevant to second grade students for this study are RIT Score, RIT to Reading, Foundational Skills, Language and Writing, Literature and Informational, and Vocabulary Use and Functions. Results are scored on a standardized Rasch Unit (RIT) scale.

Procedure

In kindergarten, experimental students were expected to use WEL for fifteen minutes per day, five days per week, and in first and second grade, experimental 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 WEL usage for the school year per group were calculated. The MAP assessment was administered to all students at the end of the 2017-2018 (second grade) school year.

Findings

Three Years of Usage vs. No Usage: Overall CAI Effects

For three years of usage compared to no usage, the experimental group included students who used WEL for more than 100 minutes during kindergarten (2015-2016), first grade (2016-2017), and second grade (2017-2018). The control group included students who used WEL for less than 100 minutes during all three school years.

Group Differences Using Independent Samples t*-tests*

Independent samples *t*-tests were conducted to examine group differences on MAP end of second grade scores between experimental and control groups (Fig. 1, Tab. 1).

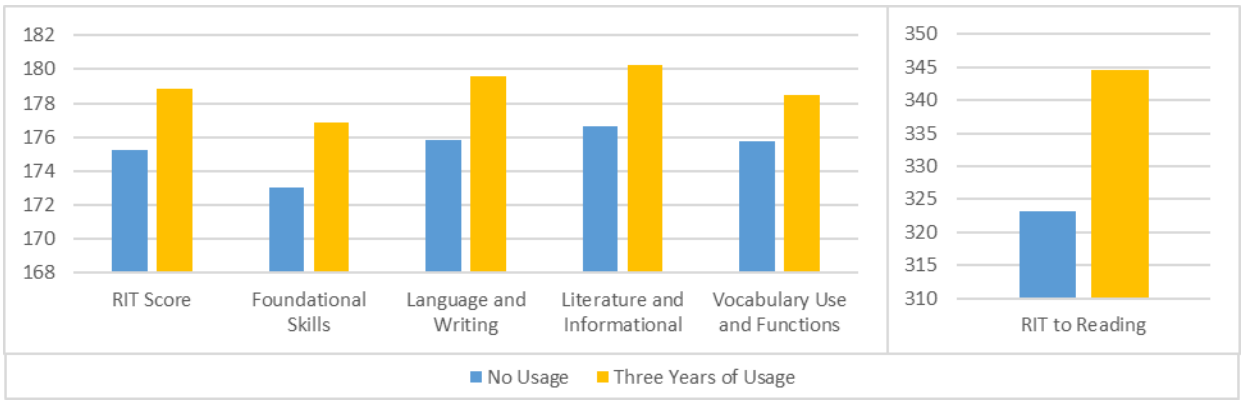

Figure 1: Three Years of Usage vs. No Usage End of Year Scores by Strand

Two Years of Usage vs. No Usage: Long-Term Effects

For two years of usage compared to no usage, the experimental group included students who used WEL for more than 100 minutes during kindergarten (2015-2016) and first grade (2016-2017) only. The control group included students who used WEL for less than 100 minutes during all three school years.

Group Differences Using Independent Samples* t-*tests

Independent samples *t*-tests were conducted to examine group differences on MAP end of second grade scores between experimental and control groups (Fig. 2, Tab. 1).

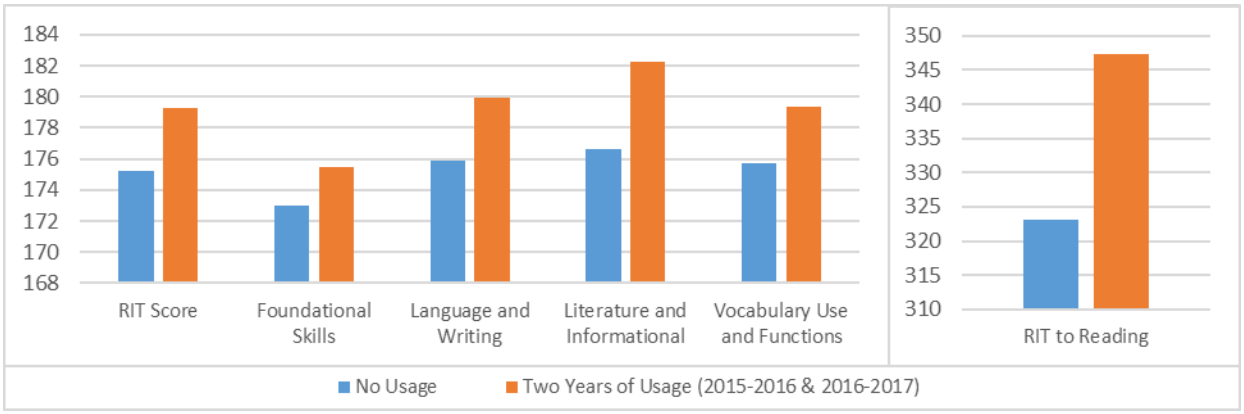

Figure 2: Two Years of Usage vs. No Usage End of Year Scores by Strand

Three Years of Usage vs. Two Years of Usage: Early Effects

For three years of usage compared to two years of usage, the experimental group included students who used WEL for more than 100 minutes during kindergarten (2015-2016), first grade (2016-2017), and second grade (2017-2018). The control group included students who used WEL for more than 100 minutes during first grade (2016-2017) and second grade (2017-2018).

Group Differences Using Independent Samples* t-*tests

Independent samples *t*-tests were conducted to examine group differences on MAP end of second grade scores between experimental and control groups (Fig. 3, Tab. 1).

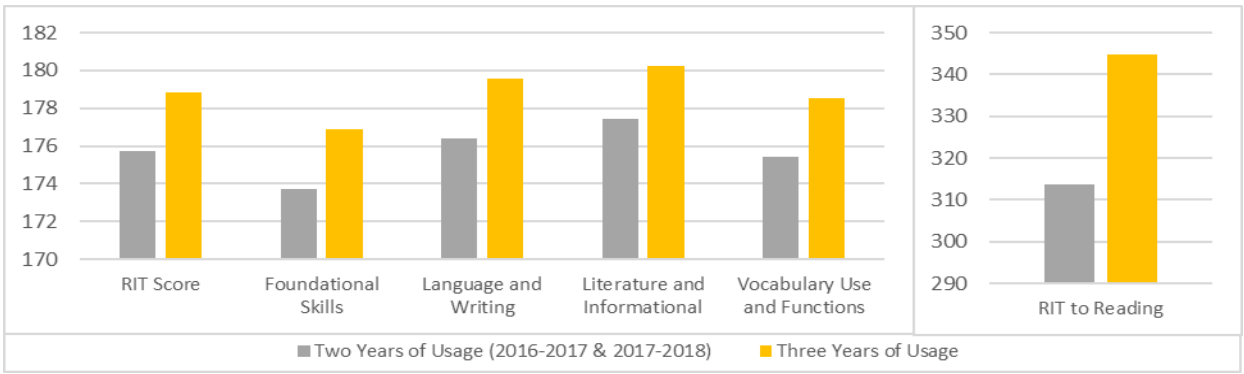

Figure 3: Three Years of Usage Vs. Two Years of Usage End of Year Scores by Strand

	Three Years of Usage vs. No Usage		Two Years of Usage vs. No Usage		Three Years of Usage vs. Two Years of Usage	
	t	*p*	*t*	*p*	*t*	*p*
RIT Score	2.25	0.03	1.92	0.06	5.06	0.00
RIT to Reading	0.89	0.37	0.89	0.37	3.46	0.00
Foundational Skills	2.20	0.03	1.14	0.26	4.78	0.00
Language and Writing	2.11	0.04	1.76	0.08	4.71	0.00
Literature and Informational	1.96	0.05	2.38	0.02	4.02	0.00
Vocabulary Use and Functions	1.53	0.13	1.51	0.13	4.47	0.00

Table 1: End of Year Strand Scores by Longitudinal Group

Conclusions

Research has shown that individualized teaching through technology can improve the early literacy skills of students, thus setting them up for future academic success (Connor et al., 2013): This study investigated how computer-assisted instruction, an individualized educational technology tool, can improve literacy assessment scores longitudinally. This study expands upon the varied educational software research by providing in-depth data concerning how students using technology consistently in the early grades perform compared to peers who do not use educational technology in the classroom at all (Flewitt, Messer, & Kucirkova, 2014; Zucker, Moody, & McKenna, 2009).

In the current study, the hypotheses were supported: Students who used the CAI program had higher literacy test scores than their control counterparts, demonstrating an overall effect of the use of CAI. Students who used, and then stopped using, the CAI program still outperformed their control counterparts one year after they stopped using the CAI program, demonstrating a long-term effect of the use of CAI. Additionally, students who started using the CAI program early in their academic careers outperformed their counterparts who started later, demonstrating an effect of the early use of CAI.

By the end of second grade, students should have fully learned how to read, and in third grade should be transitioning to reading to learn. Across all longitudinal groupings, students in the experimental groups outperformed students in the control groups, and higher literacy scores of the experimental students indicate that they are more prepared to read to learn upon entering third grade in the 2018-2019 school year. From this study, one can tentatively conclude that the more years a student uses a CAI program, the higher they will perform on literacy assessments; moreover, the earlier a student begins using a CAI program, the more profound the positive effects on their literacy scores. Overall, more rigorous, longitudinal studies are crucial to meet the need for evidence-based practices in schools, and the findings from this study add evidence in favor of educational technology.

The current longitudinal study only included one school district, so further research should investigate the longitudinal impact of the CAI program across multiple school districts. Additionally, the study did not involve investigation of demographic trends, which could add an interesting element on how students' literacy scores are impacted broken down by demographics. Overall, these findings indicate that the CAI program positively impacts literacy test scores of elementary school students across multiple school years.

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