Emergent Literacy Development and Computer Assisted Instruction

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In this mixed-methods study, researchers examined the literacy development of prekindergarten students (N = 162) randomly placed in one of two treatment groups with each receiving 15 minutes of computer-assisted literacy instruction for four months. Literacy development of a control group of children not receiving computer-assisted instruction was contrasted with the two treatment groups. All children in the study were eligible for free or reduced lunch. Responses from a semi-structured focus group of prekindergarten teachers (N = 5) were analyzed for corroboration. Although all three groups progressed in literacy development, the control group had significantly larger gains ($p < 0.01$). The effect size was moderate (eta squared = 0.63). Qualitative data supported the use of one computer program over another, but none of the teachers supported daily use of either software treatment.

Historically, instruction in literacy has occurred in first grade. This practice was based in part on the conclusions of Morphett and Washburn (1931) who found that maturity was an important factor in gauging a student's ability to begin to read. Olson (1949) and Gesell (1940; 1946) also promoted the developmental theory of reading readiness. However, Clay (1966) disavowed the maturational theories of reading readiness and coined the term "emergent literacy" to describe what children know about reading and writing before they can actually read and write conventionally. When children imitate reading and writing activities, they are practicing emergent literacy behaviors (Cecil, Baker, & Lozano, 2015).

Over the past six decades, research on emergent literacy has found a foothold in teaching practices designed for children under age six. Data from longitudinal studies reveal continuity between reading-related skills exhibited by preschool children and their reading performance in elementary school (Lonigan, Burgess, & Anthony, 2000). The National Center for Family Literacy (2004) reviewed studies that defined early literacy skills needed for young children. Skills listed in the panel's report are alphabet knowledge; phonological awareness; rapid automatic naming of letters, digits, objects, and colors; writing letters or name; phonological memory; concepts about books; print knowledge; oral language; and visual processing. Instructional practices are most useful when they are code-focused, involve shared reading, and promote language development focused on early literacy skills.

Pre-K in the United States

According to longitudinal studies, children who attended a high quality preschool were more prepared for kindergarten and outperformed their peers on language, literacy, and mathematics (Freede, 2009). Further, these positive effects persisted through elementary school at the least. In one longitudinal study, adults at age 40 who experienced a quality preschool program had higher salaries, were more likely to be employed, committed fewer crimes, and were more likely to be high school graduates (Schweinhart, et al., 2005). Thirty-nine states in the U.S. provide state-funded pre-K for children who are at-risk (WSDEL, 2013) for future high school graduation because of other hardships. In some states, children are eligible to attend free preschool if they meet all or some of the following stipulations: come from a home with a limited income, have a parent in the military, have ever been in foster care, are homeless, or do not speak or comprehend English by the time they are three years old (TEA, 2009; WSDEL, 2013).

Computer-Assisted Instruction (CAI). CAI refers to specific computer applications or supplemental activities to enhance the teacher's instruction. It differs from computer-based education and computer-based instruction, which are terms used to represent general use of computers in the classroom. The use of computer applications as a supplement to instruction promotes student interest and motivation with pictorial displays, self-pacing, and positive feedback built in the programs (Macaruso & Walker, 2008). Teacher roles are also found to be important for support of CAI. Teachers of young children who anchor their knowledge about developmentally appropriate practices regarding literacy instruction to classroom management and research support for early literacy instruction have found CAI more effective than those lacking knowledge of a specific role of the teacher (Robinson et al., 2006).

Data from various studies concerning the educational benefits from use of CAI show mixed results. A review of 46 articles (Belo, MeKenney, Voogt, & Bradley, 2016), relating to early literacy development shows that CAI supports children's early literacy development when it is used appropriately. Suitable use of CAI integrates teacher competence in technology integration with applications of technology that are developmentally appropriate. Three different types of technology-based curricula were examined in the above-mentioned literature reviewed including *Warterford Early Reading Program* (Johnson et al., Tracy and Young, 2007 and Powers and Price-Johnson, 2007), *'Ready, Set, Leap!'* (Davidson et al., 2009) and *LitTECH Outreach* (Johanson, Bell, & Daytner, 2008). Researchers reported no convincing evidence that any of these technology-based curricula resulted in significant literacy gains when compared to the control groups.

When CAI was used as an intervention with pre-K children to advance vocabulary knowledge and promote reading comprehension, the results were moderate (Spencer, et. al, 2012). Andrews (2004) showed a statistically significant positive correlation between technology integration and literacy learning for children ages 7-11. Children who used technology to enhance literacy learning had a 16% acceleration of learning compared with children without technology integration. In the same study, positive results in literacy progress were not evident for children ages 11-16.

Paterson, Henry, O'Quin, Ceprano, and Blue (2003) scrutinized the effectiveness of the *Waterford Early Reading Program* with kindergarteners in an urban public school system. The *Waterford Program* involved practice in rhyming, sound segmenting and blending, alphabet skills, and concepts of print. While findings failed to support success of the program, teacher performance variables were associated with differences in classroom performance of the kindergarteners. Students with teachers who facilitated literacy learning and maximized instructional time showed slightly more progress than the CAI students. Parr and Fung (2000) concluded "the effect of computer-assisted instruction has not been conclusively demonstrated" (p. V).

The purpose of this paper is to compare the effect of two computer programs with a control group on the literacy learning of at-risk children at one pre-K campus. The state in which this study was conducted provides free pre-K for four-year-olds who meet at least one of the following requirements: children of military parent(s), homeless, low income, or lack of English language proficiency. However, only two of the ten quality standards noted by NIEER (2014) are evident in the programing. The two quality benchmarks required by this state include comprehensive early learning standards and inclusion of at least 15 hours of in-service for teachers annually.

Students leaving this pre-K in 2013 lacked kindergarten readiness because of poor literacy skills, so school district leaders sought remedies for the lack of literacy proficiency. A pilot study was implemented in which two computer programs were examined to determine if the district should purchase the software to help pre-K students with literacy development. The study aimed to answer the following research questions:

(1) What are the differences in attainment of critical literacy skills of pre-K students before and after the treatment of (a) *Imagine Learning* (b) *Waterford Early Learning*, or (c) classroom instruction without software instruction?

(2) How did the pre-K teachers' perceive the effectiveness of *Imagine* and *Waterford Early Learning* computer programs for literacy development of students?

Theoretical Framework

Improvement of early literacy skills can be examined through the theoretical frameworks of attribution theory (Weiner, 1986) and sociocultural theory (Vygotsky, 1978). According to Weiner (1986), students' perceptions of their ability influence performance. When learners believe poor performance is beyond their control, they tend to surrender easily. Attribution theory emphasizes the importance of meeting needs of individual students and modifying learning environments to provide for optimal success. Vygotsky's sociocultural theory emphasizes the idea that social factors highly influence development. When individuals interact and explore together, cognitive development is accelerated.

Both computer programs used in this study provided for individualized learning within the classroom setting. Feedback was provided through successful accomplishment of various tasks within the program design through auditory and visual reinforcements. Since children were working independently of one another while involved in CAI, social interactions with other children and the teacher were limited.

Methods. A mixed methods approach was appropriate to determine both the literacy attainment of pre-K students and the teachers' perceptions of each computer software program. A concurrent-triangulation design (Fraenkel & Wallen, 2009) was implemented since both quantitative and qualitative data were collected and analyzed at approximately the same time. A between-subjects design with a control group was used for the quantitative phase.

Through analytic induction, focus group conversations were explored in the qualitative phase after three months of implementation. Analytic induction allows for a proposition that can be verified through qualitative data (Patton, 2002). The focus group was semi-structured with questions designed before the group met. The focus group meeting allowed pre-K teachers (N = 5) to describe their observations of student learning and experiences with and without the software support. Teacher responses to nine questions were coded to reflect observations and expectations about the results of the programs on early literacy learning.

Data Collection. Four-year-old pre-K students (N = 162) in the study attended school for a half-day (3.5 hours) and were divided into three groups: Group A (n = 51) received daily instruction of 15 minutes using *Imagine Learning* computer software; Group B (n = 60) received daily instruction of 15 minutes using *Waterford Early Learning*; and Group C (n = 51) received the regular instruction by the teacher without access to the computer programs. Students in the experimental groups rotated to the computers during the time normally allocated for learning centers. All students were native English speakers and were eligible for free or reduced lunch programs.

Pre- and post-tests using mCLASS: CIRCLE by Amplify Insight were used to measure literacy skills before and after the treatment. Although the pre- and post-tests were not identical, the skill level was similar with questions being randomized in the testing. The assessment provided brief tasks that were automatically scored and timed by a teacher using an iPad to measure development of children individually. Teachers administered both the pre- and post-assessments using this computer-based instrument.

Following discussions with school district leaders and classroom observations, researchers developed nine questions (Appendix A) to guide semi-structured focus group conversations. One researcher asked questions while one researcher took notes. Additionally, a tape recorder was used to record responses.

Imagine Learning (Group A) software was designed to engage students with interactive activities, games, and videos to promote literacy development (Imagine Learning, n.d.). Students worked at their own level and pace. *Waterford Early Learning* (Group B) was advertised as research-based and child-friendly for students in pre-K through second grade. Audio and multimedia prompts facilitated self-paced progress (Waterford, n.d.).

Data Analysis and Findings

Quantitative Findings. There were no significant differences in two areas of literacy: Letter Recognition *and* Vocabulary Recognition. The data showed significant differences in Phonemic Awareness and in a composite literacy score. The ANOVA results revealed that instructional approach had a significant effect on phonics gain, $F(2, 159) = 10.196$, $p < 0.001$ Tukey's post hoc test indicated that the Control group mean of 7.8 was significantly higher than both the Imagine group mean (M = 3.1) and the Waterford group mean (M = 4.5). The difference between the Imagine group and Waterford group was not significant (Tables 1 and 2). The effect size (eta squared = 0.114) is considered moderate (Stern, 2010).

Table 1

Descriptive Statistics for Phonics Gain

Method	Mean	Std. Deviation	N
control	7.8627	7.40546	51
Imagine	3.0980	4.26265	51
Waterford	4.5167	4.38986	60
Total	5.1235	5.79223	162

Table 2

ANOVA Summary for Phonics Gain

Tests of Between-Subjects Effects						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	613.999[a]	2	306.999	10.196	.000	.114
Intercept	4286.711	1	4286.711	142.367	.000	.472
Method	613.999	2	306.999	10.196	.000	.114
Error	4787.532	159	30.110			
Total	9654.000	162				
Corrected Total	5401.531	161				
a. R Squared = .114 (Adjusted R Squared = .103)						

Both the Waterford group (M = 32.5) and the Imagine group (M = 32.2) were found to be significantly different from the Control group (M = 31.0) when controlling for pre-test scores, $F(2, 158) = 5.883$, $p = 0.003$ (Tables 3 and 4). The effect size (eta squared = 0.069) is considered moderate (Stern, 2010).

Table 3

Descriptive Statistic for Phonics Post-Test

Method	Mean	Std. Deviation	N
control	31.0392	10.01990	51
Imagine	32.1961	8.05983	51
Waterford	32.4500	9.88480	60
Total	31.9259	9.35601	162

Table 4
ANCOVA Summary for Phonics Post-Test with Phonics Pre-Test as a Covariate

Tests of Between-Subjects Effects						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10434.718[a]	3	3478.239	150.219	.000	.740
Intercept	1249.984	1	1249.984	53.985	.000	.255
PrePhonic	10374.418	1	10374.418	448.054	.000	.739
Method	272.434	2	136.217	5.883	.003	.069
Error	3658.393	158	23.154			
Total	179214.000	162				
Corrected Total	14093.111	161				
a. R Squared = .740 (Adjusted R Squared = .735)						

The ANOVA revealed that instructional approach had a significant effect on literacy composite gains, $F(2, 159) = 5.350$, $p = .006$ (Tables 5 and 6). Tukey's post hoc test determined that the Control group mean of 19.3 was significantly higher than both the Imagine group (M = 11.8) and the Waterford group (M = 13.1). The effect size (eta squared = 0.63) is considered moderate (Stern, 2010).

Table 5

Descriptive Statistics for Literacy Composite Gain

Method	Mean	Std. Deviation	N
control	19.2745	15.56288	51
Imagine	11.7843	10.96050	51
Waterford	13.1000	10.46009	60
Total	14.6296	12.76296	162

Table 6

ANOVA Summary for Literacy Composite Gain

Tests of Between-Subjects Effects						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1653.593[a]	2	826.797	5.350	.006	.063
Intercept	34894.767	1	34894.767	225.795	.000	.587
Method	1653.593	2	826.797	5.350	.006	.063
Error	24572.184	159	154.542			
Total	60898.000	162				
Corrected Total	26225.778	161				
a. R Squared = .063 (Adjusted R Squared = .051)						

The ANCOVA revealed that the Waterford group post-test literacy composite mean of 79.1 was greater than both the Imagine group (M =7 8.5) and the Control group (M = 72.2). However, the differences between the means were found to be not significant, $F(2,158) = 2.816$, $p = 0.063$ (Tables 7 and 8). These results indicate that instructional approach had no discernable effect on literacy composite post-test scores.

Table 7

Descriptive Statistics for Literacy Composite Post-Test

Method	Mean	Std. Deviation	N
control	72.1765	22.18441	51
Imagine	78.4902	25.90704	51
Waterford	79.1167	24.64878	60
Total	76.7346	24.36391	162

Table 8

ANCOVA Summary for Literacy Composite Post-Test with Pre-Test as Covariate

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	74892.218[a]	3	24964.073	190.756	.000	.784
Intercept	5511.751	1	5511.751	42.116	.000	.210
Pre-Lit Composite	73334.972	1	73334.972	560.368	.000	.780
Method	736.929	2	368.465	2.816	.063	.034
Error	20677.369	158	130.869			
Total	1049457.000	162				
Corrected Total	95569.586	161				

a. R Squared = .784 (Adjusted R Squared = .780)

Qualitative Findings. Researchers color-coded focus group responses and categorized them in four ways: (a) positive and negative aspects of Waterford Early Learning; (b) positive and negative aspects of Imagine Learning; (c) positive and negative aspects of both programs, and (d) suggestions for future use of either/both software programs.

Teachers reported some positive perceptions about both programs. Both provided troubleshooting, personalization, instruction and practice with literacy skills, and increased readiness for technology use. Teachers' negative responses about both programs related to scheduling challenges, outdated computers, resistance of some children, and advanced difficulty level for struggling learners.

Teachers' suggestions for future use of either/both software programs is categorized in these ways: time, motivating students, literacy skill development, technological tools, and program choice. Summarily, teachers perceived daily use of either software program should be abandoned. Teachers recommended using either program 2-3 times per week in the computer lab to avoid distractions. Updated computers could prevent technology failures. Waterford was seen as the most helpful program by four of five teachers due to its use of higher order thinking and tools that help children stay on track. Imagine Learning was perceived as more of a skills-based program lacking authentic classroom connections for students. One teacher had no preference between the two programs and valued each equally.

Convergence of Findings. The control (Group C) had larger gains in the composite score than either *Imagine* (Group A) or *Waterford* (Group B). The qualitative data corroborates these findings by relating implementation issues with both programs related to scheduling, technology delays, and resistance of some children. Some children wanted to be at learning centers while others were distracted by tasks performed by peers. The control group experienced greater flexibility in time management and tasks of choice.

When composite post-test scores were examined with the pre-test as a covariate, the differences between the three groups were not statistically significant. Teachers clearly supported *Waterford Early Learning* over *Imagine Learning* for literacy development of students. One teacher commented, "I have seen students make connections from the program (*Waterford*). They learned rhyming on *Waterford* and remembered when I introduced it in class."

Implications. Educators search for strategies to improve the academic achievement of students. CAI has gained prominence in this century as an instructional tool; however, until recently few studies have been available to describe the effect of computer programs on early literacy learning. Recent studies show mixed results regarding effect on early literacy learning when CAI is implemented as part of the curriculum. This study provides evidence that the classroom teacher provides as much or more instructional support when compared with CAI in early literacy development. Pre-K students in this study may have had poor performance due to factors beyond their control as described when students cried or ignored the teacher when asked to use either computer program. This behavior is supported by attribution theory (Weiner, 1986) in which students believe they are incapable of success, so they easily give up. Additionally, sociocultural theory (Vygotsky, 1978) provides additional support for poor performance with CAI since some children worked on the computer programs while others worked in table groups. Results of this study support previous findings of Belo et al., 2016, concerning CAI use with young children. However, in the Belo study, CAI was used with kindergarten children. Implications from this study suggest that independent practice may not be developmentally appropriate for some children of pre-K age who desire more interaction with peers and the teacher. More research is needed across age groups and types of computer software to determine broader findings on the effects of computer assisted instruction on literacy skill development.

References

Andrews, R. (2004). *The impact of ICT on literacy education*. New York: RoutledgeFalmer.

Belo, N., MeKenney, S., Voogt, J., & Bradley, B. (2016). Teacher knowledge for using technology to foster early literacy: A literature review. *Computers in Human Behavior*, *60*, 372-383.

Clay, M. M. (1966). *Emergent reading behavior* (Unpublished doctoral dissertation). University of Auckland, New Zealand.

Cotton, K. (1991). Computer-assisted instruction. *Northwest Regional Educational Laboratory School Improvement Research Series* (Series V, Close-Up #10). Retrieved from Education Northwest website: http://educationnorthwest.org/sites/default /files/Computer-AssistedInstruction.pdf

Dillon, A. and Zhu, E. (1997). Designing Web-Based Instruction: A Human-Computer Interaction (HCI) Perspective. In B. Khan (ed.) *Web-Based Instruction* (pp. 221-225), Englewood Cliffs, NJ: Educational Technology Publications.

Fraenkel, J.R., & Wallen, N.E. (2009). *How to design and evaluate research on teaching* (7th ed.). New York: McGraw-Hill.

Frede, E., Kwanghee, J., Barnett, S.W., & Figueras, A. (2009). The APPLES blossom: Abbott preschool program longitudinal effects study (APPLES), preliminary results through 2nd Grade. Retrieved from the National Institute for Early Education Research website: http://nieer-www1.rutgers.edu/pdf/apples_second_grade_results.pdf

Hecht, S. A, & Close, L. (2002). Emergent literacy skills and training time uniquely predict variability in responses to phonemic awareness training in disadvantaged kindergartners. *Journal of Experimental Child Psychology, 82*, 93–115.

Imagine Learning Programs (n.d.). In *Imagine Learning*. Retrieved from http://www.imaginelearning.com/programs/imaginelearning/

Ingersoll, R. (2003). *Is there really a teacher shortage*. Retrieved from the University of Pennsylvania Grade School of Education website: http://repository.upenn.edu/cgi/viewcontent.cgi?article=1133&context=gse_pubs

Macaruso, P. & Walker, A. (2008). The efficacy of computer assisted instruction for advancing literacy skills in kindergarten students. *Reading Psychology*, *29*, 266–287

National Center for Family Literacy. (2004). *The report of the national early literacy panel.* Washington, D.C.: United States Government.

Parr, J. M., & Fung, I. (2000). *A review of the literature on computer-assisted learning, particularly integrated learning systems, and outcomes with respect to literacy and numeracy.* Retrieved from http://www.educationcounts.govt.nz/__data/assets/pdf_file/0004/7672/A-Review-of-the-Literature-on-Computer-Assisted.pdf

Paterson, W. A., Henry, J.J., O'Quin, K., Ceprano, M.A. & Blue, E.V. (2003). Investigating the effectiveness of an integrated learning system on early emergent readers. *Reading Research Quarterly, 38*, 172–207.

Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage.

Robinson, L., Johanson, J., Schneider, C., & Hutinger, P. (2006). *Final report: Interactive technology literacy curriculum online (ITLC Online).* Macomb, IL: Western Illinois University. (ERIC Document Reproduction Service No. ED495396)

Schweinhart, L. J., Montie, J., Xiang, Z., Barnett, W. S., Belfield, C. R., & Nores, M. (2005). *Lifetime effects: The HighScope Perry Preschool study through age 40*: *Summary, conclusions, and frequently asked questions*. Retrieved from the HighScope Educational Research Foundation website: http://www.highscope.org/file/specialsummary_ rev2015_01.pdf

Spencer, E.J., Goldstein, H., Sherman, A., Noe, S., Tabbah, R., Ziolkowski, R. & Schneider, N. (2012). Effects of an automated vocabulary and comprehension intervention an early efficacy study. *Journal of Early Intervention 34*(4), 195-221.

Stern, (2010). *Statistics for the behavioral sciences. A visual approach to SPSS for windows: A guide to SPSS 17.0.* Boston, MA: Allyn & Bacon.

Washington State Department of Early Learning, (WSDEL). (2013). *Pre-kindergarten programs: An overview and comparison with other states.* Retrieved from http://leg.wa.gov/Senate/Committees/EDU/Documents/UniversalVoluntaryPreschool.pdf

Waterford Early Learning (n.d.) In *Waterford*. Retrieved from http://www.waterford.org/waterford-early-learning/

Weiner, B. (1986). *An attributional theory of motivation and emotion*. New York: Springer-Verlag.

Wise, B., Ring, J., & Olson R.K., (2000). Individual differences in gains from computer-assisted remedial reading. *Journal of Experimental Child Psychology*, *77*, 197–235.

Appendix A

Focus Group questions

1. Describe the implementation process of the programs. What types of issues did you encounter? Were there challenges?
2. Describe the ease of use of the programs for students. Were they user-friendly?
3. Describe the student's responses to using each program. What behaviors did you observe?
4. Did each program motivate or engage students? How do you know? Describe student behaviors or comments to support your observation.
5. For teachers who used both programs, which one do you project will produce better results on the 7 literacy skills?
6. Did you observe a transfer of learning to classroom activities/instruction for either program?
7. Were the programs beneficial to students? How? Describe how you know?
8. Were the teacher supplemental resources useful to you? Which ones and why?
9. Do you have any suggestions for using the programs during the instructional day? More time? Less time? None?