Using Technology to Improve Reading and Math Scores for the Digital Native

Haya Shamir
hayashamir@waterford.org

Kathryn Feehan
kathrynfeehan@waterford.org

Erik Yoder
erikyoder@waterford.org

Waterford Research Institute
United States

Abstract: This study investigates the impact of adding an adaptive computer assisted instruction (CAI) program to current Head Start curriculum on low SES, African American pre-kindergarten students' reading and math gains. Students completed pre- and post-testing with a standardized reading and math measure in order to determine relative gains. The results show that students using the program had significant reading and math gains over those in the control group. These results suggest that an adaptive computer assisted instruction program can benefit pre-kindergarten students by developing early reading and math skills more effectively than in-class instruction alone.

Introduction

Due to the rapid emergence of digital technology in the last decades of the twentieth century, education has had to adapt to the new generation of digital natives (Prensky, 2001). The students of today are experiential learners, and current schooling practices are adapting to relate to this generation's interest in games-based learning (Bittman, Rutherford, Brown, & Unsworth, 2011). Bridging the gap from home to school, researchers have encouraged the development of technology in schools that is relative to the amount of technology that children are exposed to in the home (Beschorner & Hutchison, 2013; Plowman, Stevenson, Stephen, & McPake, 2012). However, research has led to conflicting findings on the success of technology on digital natives in school, and there is still a gap in research on the relationship between young children's learning and developmentally appropriate technology in early reading instruction (Burnett, 2010; Hsin, Li, & Tsai, 2014). To adapt to the generation of digital natives, the United States has invested greatly in educational technology over the past two decades (Lei, 2010). Recent efforts to improve reading instruction on a national scale, like the No Child Left Behind Act and its accompanying Early Reading First program, have moved public schools toward setting more specific goals for accountability and instructional methods for reading (U.S. Department of Education, 2010); however, results have not proven to be unequivocally positive. Scores from the 2013 NAEP show that progress in early reading achievement continues to be very slow, even though progress has been made by lower-performing students in the early grades. The 2013 test showed no significant changes in racial/ethnic gaps, gender gaps, or gaps by type of school when compared to scores from 2011, and reading average scores among fourth-graders did not improve at all (National Center for Education Statistics [NCES], 2013). Making improvements to early reading instruction continues to present a significant problem for both educators and policymakers.

An additional area of concern for early education with little change is mathematics. Studies of math achievement over the last couple decades have shown that students in the United States consistently perform worse on math assessments than their peers in other nations. Scores from 2015 NAEP show a significant decrease in scores and continued gaps across genders, ethnicities, and demographic areas in both fourth and eighth grades as well as highlighting a deeper concern for urban districts, with 50% showing a decrease in one or both grades since 2013 (NCES, 2015). The National Center for Education Statistics reports that the Trends in International Mathematics and Science Study (TIMSS), a respected international report comparing the practical educational abilities of students from different nations, rates the United States 11th of 18 nations in mathematics (2011a). Empirical evidence also suggests that differences between East Asian and United States students' fundamental mathematic understandings exist even prior to formal schooling (Sakakibara, 2014). Several other international indicators show that U.S.

students consistently perform below their international counterparts in math and science. These differences are not only evident in junior high and high school but also in the early grades (Klein & Starkey, 2004). On the 2011 TIMSS test, only 13% of U.S. fourth graders achieved an advanced level, compared with 43% of Singaporean fourth graders. In addition, 96% of U.S. fourth grade students, and 92% of eighth grade students scored at the 'Low' benchmark for the 2011 TIMMS (NCES, 2011a).

The lack of achievement in mathematics is particularly poignant due to the fact that the United States spends 35% more money on elementary and secondary education than the OECD average (NCES, 2011b). In addition, within the United States, high school, middle school, elementary school, and even pre-kindergarten children from low SES households perform significantly lower on assessments of basic mathematical knowledge than their middle-class counterparts (Klein & Starkey, 2004). This research has revealed both the need to raise math standards, and the necessity to routinely assess young children prior to kindergarten in order to determine whether they have the foundational math skills requisite for academic success in formal school.

Adaptive Curriculum for Technology-Driven Generation

The Head Start program, founded in 1965, is an attempt to target low socioeconomic status students and families in the United States in need of pre-school instruction. Head Start promotes school readiness of young children from low-income families. Head Start involves "teachers facilitat[ing] individualized learning experiences to promote children's readiness for school and beyond. Through planned and spontaneous instruction, relationships with adults, and play, children grow in language and literacy, early math and science concepts, and social and emotional development" (Head Start, 2015). Additionally, Head Start school readiness is measured by skills in five domains: Language and Literacy, Cognition and General Knowledge, Approaches to Learning, Physical Development and Health, and Social and Emotional Development.

One way to individualize instruction is through the use of technology. Lei (2010) found that the quantity of technology in education is not significantly effective unless the quality and adaptability of the technology is proficient. The Waterford Early Learning (WEL) program, an adaptive CAI, offers a comprehensive computer-adaptive reading, math, and science curriculum for pre-kindergarten through second-grade students. WEL is divided into two subsequent programs, each of which is designed to address reading, math, and science skills. WEL curriculum starts with an initial diagnostic test that determines the appropriate beginning level of the student. From that point on, the sequence continues automatically and offers individual sequenced set of learning activities. The sequencer determines activities to introduce, instruct, practice, and assess based on students' performance on specific reading, math, and science skills. The program is intended to offer a complete curriculum for these grades. Although often used in conjunction with traditional classroom instruction, WEL also provides offline student and teacher components, and can therefore be used as a comprehensive, stand-alone curriculum.

The WEL software presents a wide range of multimedia-based activities in an adaptive sequence tailored to each student's individual rate of growth. Its reading instructional "strands" include phonological awareness, phonics, comprehension and vocabulary, reading fluency and language concepts (i.e., print concepts, grammar, and mechanics of written and spoken language). The WEL math and science instruction "strands" include science, measurement and data, operations and algebraic thinking, numbers and operations, and geometry.

The current study investigates the impact of adding an adaptive computer assisted instruction program to an existing Head Start curriculum and its impact on low socioeconomic students' reading and math scores. Specifically, the programs utilized are the Waterford Early Reading Program (ERP) and the Waterford Early Math and Science Program (EMS).

Methodology

Participants

Participants were enrolled in Head Start pre-kindergarten programs in Florida and used Waterford Early Learning program during the 2014-2015 school year.

For the Waterford Early Reading Program (ERP), the experimental group consisted of 653 pre-kindergarten students with over 900 minutes of usage for the school year. The control group consisted of 67 pre-kindergarten students who used the ERP for less than 300 minutes during the 2014-2015 school year.

For the Waterford Early Math and Science (EMS), the experimental group consisted of 183 pre-kindergarten students with over 1000 minutes of usage for the 2014-2015 school year. The control group consisted of 372 pre-kindergarten students who used the EMS for less than 300 minutes during the 2014-2015 school year.

Measurements

Students in the experimental group were expected to use the program for 15 minutes per day for three to five days per week. Students were administered Florida's Voluntary Prekindergarten Assessment (VPK), a standardized state assessment during the fall, winter, and spring of the 2014-2015 school year. The assessment included sub strands for Oral Language Vocabulary, Phonological Awareness, Print Knowledge, and Math.

Findings

Early Reading Program, Group differences using ANCOVA

For ERP users, an ANCOVA examining group differences in spring scores while covarying fall scores was conducted, see Figure 1.

Oral Language Vocabulary

Analysis of spring scores, while covarying for fall scores, revealed a significant difference between groups $F(1, 682) = 38.408$, $p<.01$ due to higher spring scores for students who used Waterford (M=19.64) than for control students (M=17.42). Effect size (d=.73).

Phonological Awareness

Analysis of spring scores, while covarying for fall scores, revealed a significant difference between groups $F(1, 682) = 115.118$, $p<.01$ due to higher spring scores for students who used Waterford (M=11.92) than for control students (M=8.59). Effect size (d=1.28).

Print Knowledge

Analysis of spring scores, while covarying for fall scores, revealed a significant difference between groups $F(1, 681) = 76.970$, $p<.01$ due to higher spring scores for students who used Waterford (M=11.13) than for control students (M=8.78). Effect size (d=1.1).

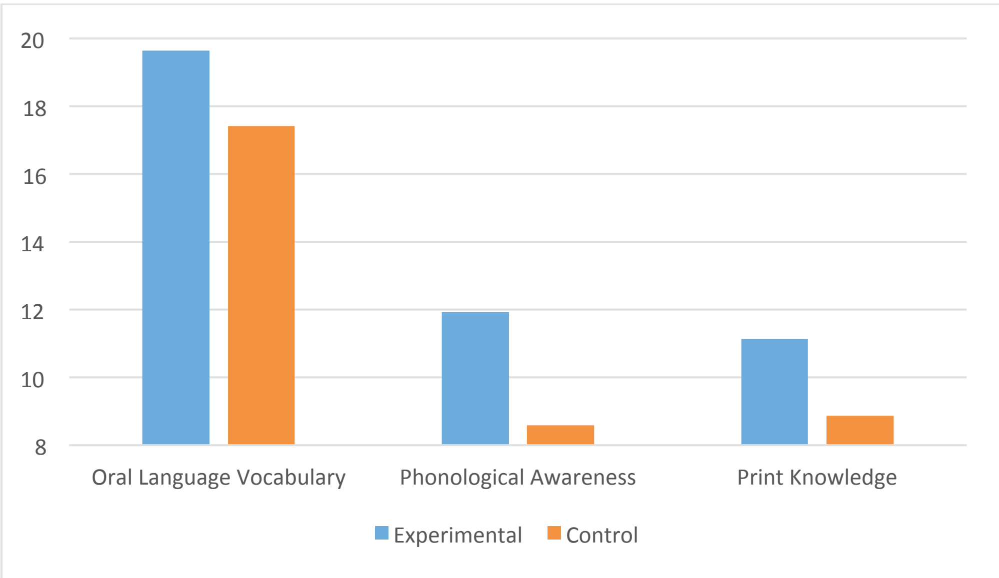

Figure 1: Spring Sub Strand Scores, covarying for Fall

Oral Language Vocabulary

Further analysis was conducted to examine the effects of gender, ELL status, ethnicity, and special education status on spring oral language vocabulary scores. Four separate ANCOVA were conducted that examined the effect of demographics and Waterford curriculum on oral language vocabulary spring scores while covarying for oral language vocabulary fall scores, see Figure 2.

Gender

There is no significant interaction between the effects of gender and Waterford curriculum on oral language vocabulary spring scores, *F*(1,674) = .380, p=.538. Simple effects analysis showed that for males, F(1,674) = 22.404, p<.01, and females, F(1,674) = 18.051, p<.01, students in the experimental group significantly outperformed students in the control group.

ELL Status

There is no significant interaction between the effects of ELL status and Waterford curriculum on oral language vocabulary spring scores, *F*(1,674) = 1.319, p=.251. Simple effects analysis showed that for ELL, F(1,674) = 18.431, p<.01, and not ELL, F(1,674) = 22.281, p<.01, students in the experimental group significantly outperformed students in the control group.

Ethnicity

There is a significant interaction between the effects of ethnicity and Waterford curriculum on oral language vocabulary spring scores, *F*(4,666) = 2.43, p<.05. Simple effects analysis showed that for African Americans, F(1,666) = 16.234, p<.01, Asians, F(1,666) = 13.118, p<.01, and Hispanics, F(1,666) = 14.508, p<.01, students in the experimental group significantly outperformed students in the control group. Caucasians students' scores in the experimental group were slightly higher than Caucasian students' scores in the control group, but the difference was not significant, F(1,666) = 1.457, p=.228.

Special Education Status

There is no significant interaction between the effects of special education status and Waterford curriculum on oral language vocabulary spring scores, *F*(2,671) = 2.802, p=.061. Simple effects analysis showed that for language impaired, F(1,671) = 5.895, p<.05, speech impaired, F(1,671) = 13.809, p<.01, and no special education status identified, F(1,671) = 21.187, p<.01, students in the experimental group significantly outperformed students in the control group.

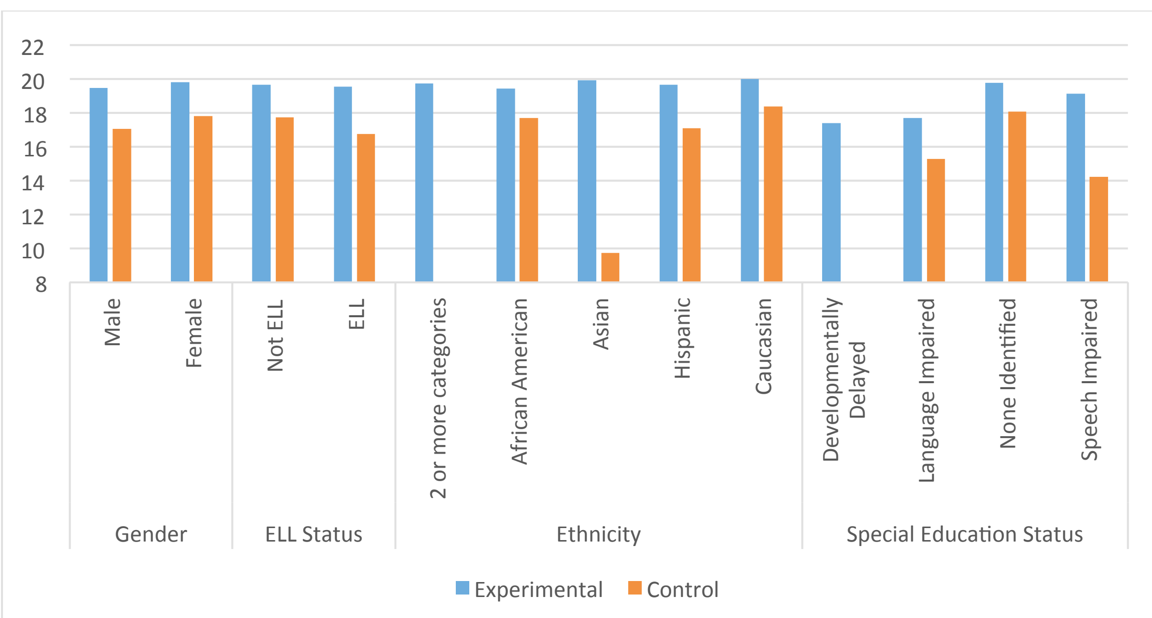

Figure 2: Oral Language Vocabulary Spring Scores, by Demographics

Phonological Awareness

Further analyses were conducted to examine the effects of gender, ELL status, ethnicity, and special education status on spring phonological awareness scores. Four separate ANCOVA were conducted that examined the effect of demographics and Waterford curriculum on phonological awareness spring scores while covarying for phonological awareness fall scores, see Figure 3.

Gender

There is a significant interaction between the effects of gender and Waterford curriculum on phonological awareness spring scores, $F(1,674) = 4.798$, $p<.05$. Simple effects analysis showed that for males, $F(1, 674) = 79.464$, $p<.01$, and females, $F(1,674) = 41.974$, students in the experimental group significantly outperformed students in the control group.

ELL Status

There is no significant interaction between the effects of ELL status and Waterford curriculum on phonological awareness spring scores, $F(1,674) = .050$, $p=.823$. Simple effects analysis showed that for ELL, $F(1,674) = 34.863$, $p<.01$, and not ELL, $F(1,674) = 82.373$, $p<.01$, students in the experimental group significantly outperformed students in the control group.

Ethnicity

There is no significant interaction between the effects of ethnicity and Waterford curriculum on phonological awareness spring scores, $F(4,666) = 1.928$, $p=.104$. Simple effects analysis showed that for African Americans, $F(1, 666) = 56.425$, $p<.01$, Asians, $F(1,6) = 11.613$, $p<.01$, Hispanics, $F(1, 666) = 29.363$, $p<.01$, and Caucasians, $F(1, 666) = 12.163$, $p<.01$, students in the experimental group significantly outperformed students in the control group.

Special Education Status

There is no significant interaction between the effects of special education status and Waterford curriculum on phonological awareness spring scores, $F(2,671) = 2.652$, $p=.071$. Simple effects analysis showed that for language impaired, $F(1,671) = 28.169$, $p<.01$, speech impaired, $F(1,671) = 14.301$, $p<.01$, and no special education status identified, $F(1,671) = 71.918$, $p<.01$, students in the experimental group significantly outperformed students in the control group.

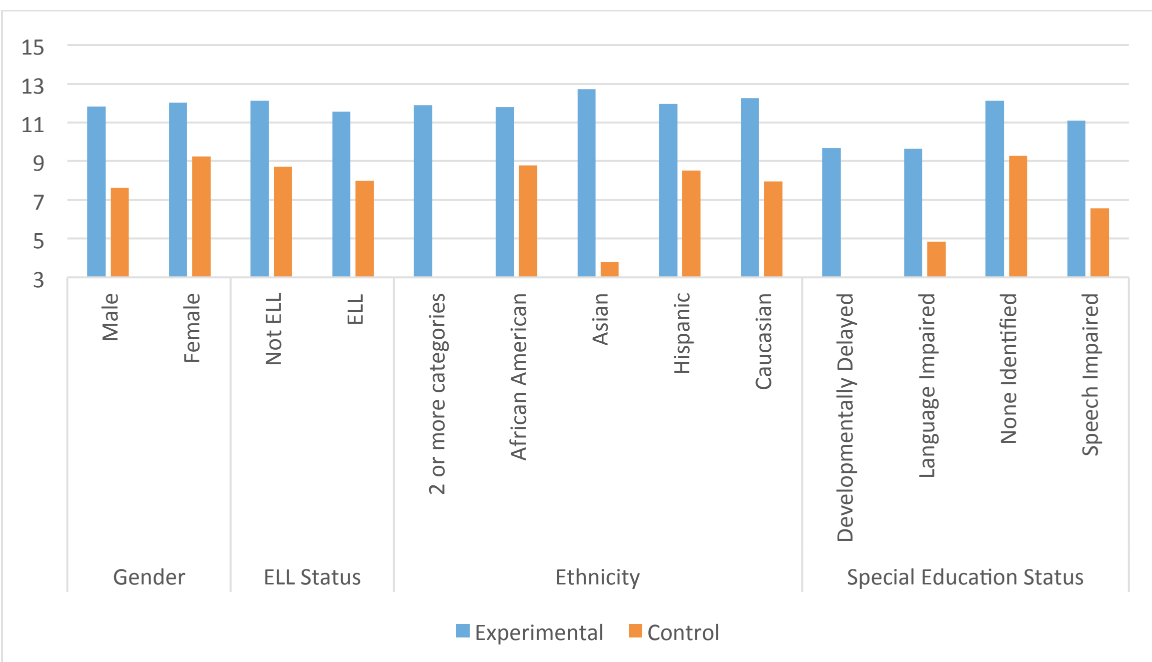

Figure 3: Phonological Awareness Spring Scores, by Demographics

Print Knowledge

Further analysis was conducted to examine the effects of gender, ELL status, ethnicity, and special education status on spring print knowledge scores. Four separate ANCOVA were conducted that examined the effect of demographics and Waterford curriculum on print knowledge spring scores while covarying for print knowledge fall scores, see Figure 4.

Gender

There is a significant interaction between the effects of gender and Waterford curriculum on print knowledge spring scores, $F(1,673) = 16.137$, $p<.01$. Simple effects analysis showed that for males, $F(1, 673) = 80.384$, $p<.01$, and females, $F(1,673) = 14.682$, $p<.01$, students in the experimental group significantly outperformed students in the control group.

ELL Status

There is a significant interaction between the effects of ELL status and Waterford curriculum on print knowledge spring scores, $F(1,673) = 8.447$, $p<.01$. Simple effects analysis showed that for ELL, $F(1,673) = 49.859$, $p<.01$, and not ELL, $F(1, 673) = 34.195$, $p<.01$, students in the experimental group significantly outperformed students in the control group.

Ethnicity

There is a significant interaction between the effects of ethnicity and Waterford curriculum on print knowledge spring scores, $F(4,665) = 2.800$, $p<.01$. Simple effects analysis showed that for African Americans, $F(1, 665) = 25.397$, $p<.01$, Hispanics, $F(1,665) = 45.821$, $p<.01$, and Caucasians, $F(1,665) = 7.330$, $p<.01$, students in the experimental group significantly outperformed students in the control group. Asian students' scores in the experimental group were slightly higher than Asian students' scores in the control group, but the difference was not significant, $F(1,665) = 2.273$, $p=.132$.

Special Education Status

There is a significant interaction between the effects of special education status and Waterford curriculum on print knowledge spring scores, $F(2,670) = 4.326$, $p<.05$. Simple effects analysis showed that for language impaired, $F(1,670) = 30.120$, $p<.01$, speech impaired, $F(1,670) =9.250$, $p<.01$, and no special education status identified, $F(1, 670) = 43.973$, $p<.01$, students in the experimental group significantly outperformed students in the control group.

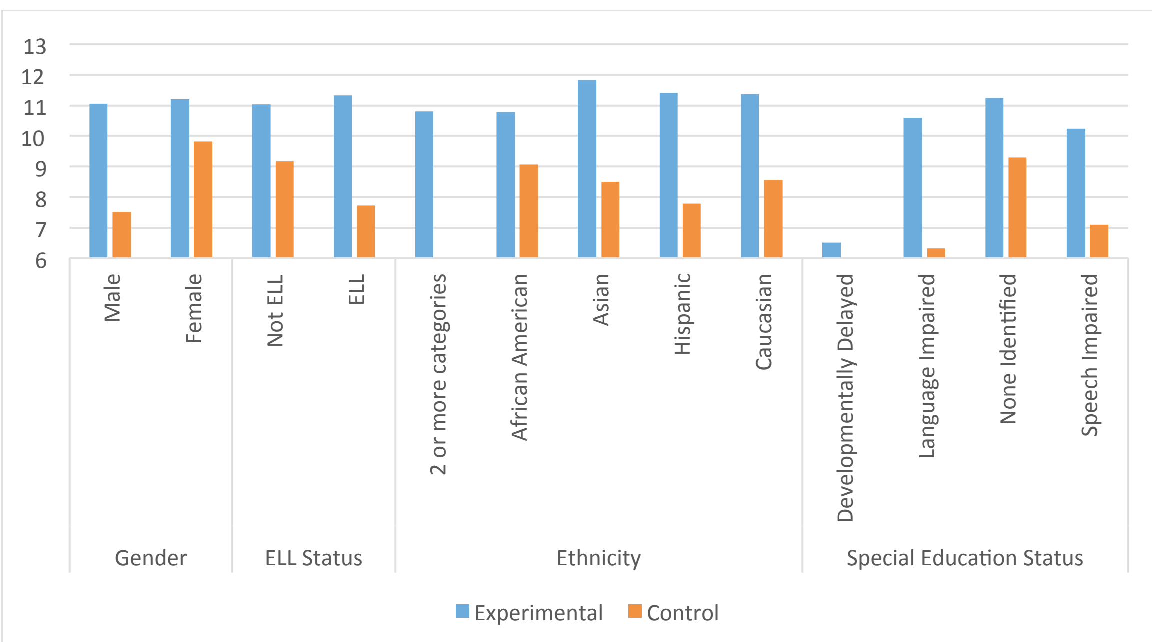

Figure 4: Print Knowledge Spring Scores, by Demographics

Early Math and Science Program, Group differences using ANCOVA

For EMS users, an ANCOVA examining group differences in spring scores while covarying for fall scores was conducted, see Figure 5.

Math

Analysis of spring scores, covarying for fall, revealed a significant difference between groups, $F(1,517) = 72.919$, $p<.01$. due to higher spring scores for students who used Waterford (M=15.93) than for control students (M=13.11). Effect size (d=.73).

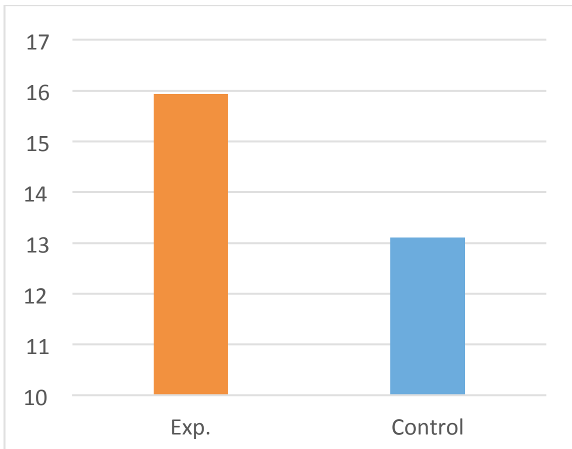

Figure 5: Math Spring Scores, covarying for Fall

Further analysis was conducted to examine the effects of gender, ELL status, ethnicity, and special education status on spring math scores. Four separate ANCOVA were conducted that examined the effect of demographics and Waterford curriculum on math spring scores while covarying for math fall scores, see Figure 6.

Gender

There is no significant interaction between the effects of gender and Waterford curriculum on math spring scores, $F(1,512) = 2.620$, $p=.106$. Simple effects analysis showed that for males, $F(1,512) = 56.602$, $p<.01$, and females, $F(1,512) = 22.363$, $p<.01$, students in the experimental group significantly outperformed students in the control group.

ELL Status

There is no significant interaction between the effects of ELL status and Waterford curriculum on math spring scores, $F(1,476) = 3.81$, $p=.051$. Simple effects analysis showed that for ELL, $F(1,476) = 47.647$, $p<.01$, and not ELL, $F(1,476) = 24.804$, $p<.01$, students in the experimental group significantly outperformed students in the control group.

Ethnicity

There is no significant interaction between the effects of ethnicity and Waterford curriculum on math spring scores, $F(4,505) = 2.105$, $p=.079$. Simple effects analysis showed that for African Americans, $F(1,505) = 12.364$, $p<.01$, Hispanics, $F(1,505) = 60.630$, $p<.01$, and Caucasians, $F(1,505) = 5.933$, $p<.01$, students in the experimental group significantly outperformed students in the control group. Asian and multiple ethnicity students' scores in the experimental group were slightly higher than Asian students' scores, $F(1,505) = .586$, $p=.444$, and multiple ethnicity students' scores, $F(1,505) = 1.939$, $p=.164$, in the control group respectively, but the differences were not significant.

Special Education Status

There is no significant interaction between the effects of special education status and Waterford curriculum on math spring scores, $F(3,508) = .685$, $p=.562$. Simple effects analysis showed that for speech impaired, $F(1,508) = 6.287$, $p<.01$, and no special education status identified, $F(1,508) = 62.411$, $p<.01$, students in the experimental group significantly outperformed students in the control group. Language impaired students' scores in the experimental group were slightly higher than language impaired students' scores in the control group, but the difference was not significant, $F(1,508) = .551$, $p=.458$.

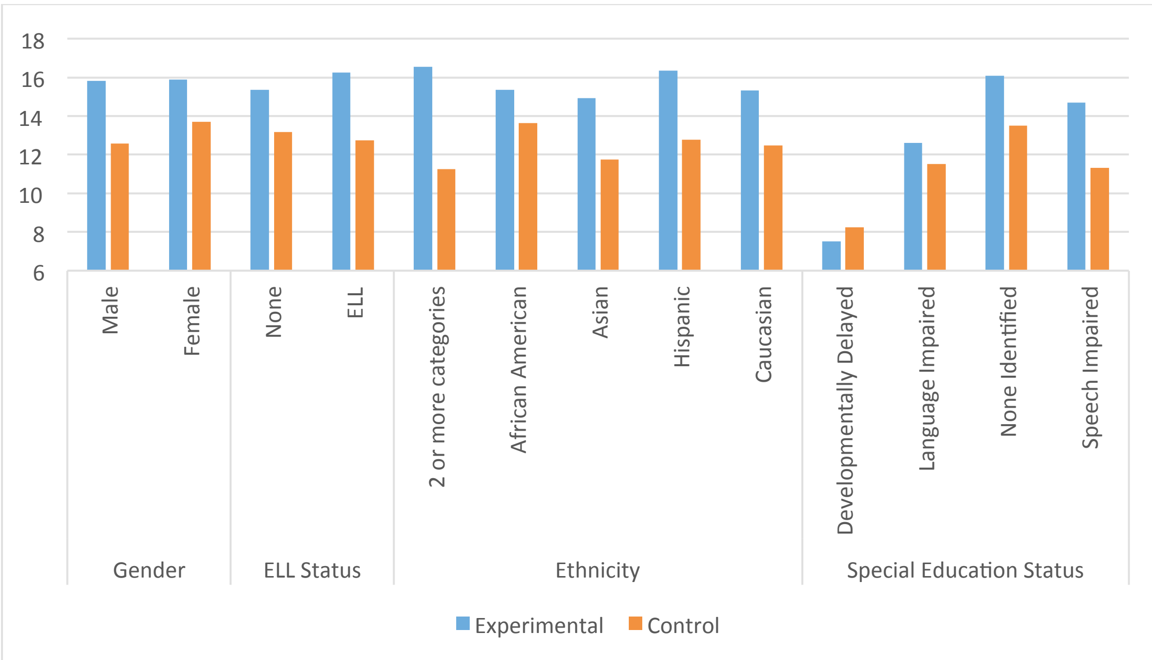

Figure 6: Math Spring Scores, by Demographics

Conclusions

Early childhood education programs are important to bolster intellectual development, allowing children to build a solid learning base. The benefits of effective early childhood education may be especially important for disadvantaged students, since the early skill gap between them and their more advantaged counterparts can persist throughout their academic life span (DeCicca & Smith, 2013). Our findings suggest that the computer assisted instruction software, specifically the WEL program, has been effective in helping participants attain the emergent literacy, reading, and math skills they need for early academic success. Based on past results in the United States (Macaruso & Walker, 2008; Powers & Price-Johnson, 2007), we expected to see significantly greater gains in early reading and math skills for students using CAI software as part of their curriculum compared to students only receiving regular classroom instruction.

It is apparent that technology can be a very useful tool in education, especially with the emergence of the generation of digital natives in recent decades. However, despite an increase in access across multiple platforms, including computers and even mobile devices, use of technology in the classroom remains infrequent, especially in early childhood education (Wartella, Schomburg, Lauricella, Robb, & Flynn, 2010). In light of this, the U.S. Department of Education released the National Education Technology Plan in 2010. The plan promotes student-centered learning with technology in hopes of improving student achievement (U.S. Department of Education, 2010). Further still, the Federal Communications Commission announced a 3 billion dollar investment in conjunction with other investments by private technology companies in an attempt to close the technology gap that exists between schools across the nation (Bidwell, 2014).

Despite the challenges faced by integrating technology in education, recent developments to encourage its use, coupled with past and emergent research to further garner its efficacy, provides an encouraging outlook. The current study supported our hypotheses; on most measured skills the treatment group made significantly greater gains than the control group. Where gains were not seen, it is important to keep in mind that as with any educational intervention, an important factor that may profoundly influence outcomes is the level of implementation. These findings imply that adaptive computer assisted instruction programs, when coupled with a program that promotes school readiness like Head Start, benefit pre-kindergarten students by developing early reading and math skills more effectively than in-class instruction alone. Overall, the use of adaptive, individualized instruction and computers in schooling is an effective method for teaching early literacy and math skills for students.

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