Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 11, pp.61814-61826, November, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

COMPUTER USE AND READING ACHIEVEMENT: EVIDENCE FROM THE 2015 NAEP FOURTH GRADE READING SCORES

[1]Julie LaDell-Thomas and *,[2]Mingyuan Zhang

[1]Distance Education Librarian
[2]Professor of Education, Department of Teacher Education and Professional Development
Central Michigan University, USA

ARTICLE INFO

Article History:
Received 19th August, 2017
Received in revised form
29th September, 2017
Accepted 25th October, 2017
Published online 30th November, 2017

Key words:
Reading proficiency,
PD,
Use of computer.

ABSTRACT

This study presented a secondary analysis of the National Assessment of Educational Progress (NAEP) dataset. The paper examined the impact of reading-related computer use on 2015 NAEP reading scores of fourth grade students, particularly those of lower socioeconomic status. The findings include (1) the average scale score of students of lower socioeconomic status was significantly lower (M=209, SD=.4) than students of higher socioeconomic status (M=237, SD=.3) by 28 points. (2) The average score of students when teachers had received training in integrating technology in the past two years was significantly higher ((M=224, SD=.5) than when teachers had not received training (M=220, SD=.7) by four points. Moreover, (3) Students who reported that they did not have a computer at home (M=209, SD=.7) scored significantly lower than students who did have a computer at home (M=225, SD=.4) by 16 points. These findings may indicate that concerns about the inequity of technology resources across what is termed the "digital divide" are warranted, and teacher technology training has a positive impact on student academic achievement.

Citation: Julie LaDell-Thomas and Mingyuan Zhang, 2017. "Computer use and reading achievement: Evidence from the 2015 naep fourth grade reading scores", *International Journal of Current Research*, 9, (11), 61814-61826.

INTRODUCTION

Reading ability is at the core of successful learning, and in today's increasingly digital environment, technology is being used in new and promising ways to build knowledge and support the development of reading skills. Given the importance of developing reading proficiency at an early age, educators, researchers, and policymakers continue to work towards building a stronger foundation of reading and literacy in young learners. Advancements in educational technology have provided an opportunity to use computer applications to help develop fluency, vocabulary, and comprehension, and research has begun to demonstrate the effectiveness of some of these efforts. A number of studies have explored the relationship between computer use and reading achievement. Some researchers have found that improved reading is associated with the integration of computer-based instruction in schools (Lai *et al*., 2006; O'Dwyer *et al*., 2005); but Cheung and Slavin, 2012) found that "the types of supplementary computer-assisted instruction programs that have dominated the classroom use of educational technology in the past few decades were not found to produce educationally meaningful effects in reading for K-12 students" (p.198). Computer use has also proliferated in home environments. The proportion of children with home access to computers has grown steadily in recent years, from 15 %in 1984 to 78.5 % in 2015 (Child Trends Data Bank, 2015). Some studies (House, 2007; Espinosa *et al*., 2006) have indicated that students who use computers at home earn higher reading achievement scores, while others (Vigdor and Ladd, 2010; Malamud and Pop-Eleches, 2011) have found negative effects. Whether positive or negative, the "household media environment" (computers, televisions, media players, etc.) appears to be associated with educational outcomes (Borzekowski and Robinson, 2005), and as the influence of technology in daily life grows more prevalent, this association merits further study. Children in households with lower socioeconomic levels have more limited access to computers and books, and spend more hours watching television (Espinosa *et al*., 2006). In addition, students in fourth and fifth grade tend to experience a "deceleration in reading skill development" as they transition to the upper grades, a phenomenon that is especially pronounced in students of lower socioeconomic status (Suhr *et al*., 2010). While many studies have investigated the impact of computers on reading achievement, the lack of consensus, along with the need to address a critical period in reading development for low income elementary students, provide a strong rationale for further research that will identify ways in which the use of technology (at home or at school) can support reading achievement. Teachers' underlying attitudes and expectations can also influence the degree to which students

Corresponding author: **Mingyuan Zhang,**
Professor of Education, Department of Teacher Education and Professional Development, Central Michigan University, USA.

benefit from computer-supported learning, so research about technology integration should also consider factors related to teacher practices. The purpose of this study was to examine the impact of reading-related computer use on 2015 NAEP reading scores of fourth grade students, particularly those of lower socioeconomic status. The author reviewed literature related to 1) reading, technology, and socioeconomic status, 2) reading, technology and teachers, 3) reading and school use of computers, 2) reading and home use of computers. Then, the author used recent NAEP reading scores for fourth graders to explore the following questions:

1. How are NAEP reading scores related to students' socio-economic status (as determined by student eligibility for National School Lunch Program)
2. How are NAEP reading scores related to teacher training in integrating computers into instruction in past two years
3. How are NAEP reading scores related to reading-related school use of computers
4. How are NAEP reading scores related to using a computer at home
5. How are NAEP reading scores related to at home access to the Internet

This study could provide teachers, administrators, and policymakers with updated information about the relationship between the use of computers (at home and at school) and reading achievement at a critical time for developing readers. Additionally, this research examined reading achievement as it relates to teachers' training on technology integration, providing analysis that may be useful for understanding how an investment in teacher development can foster student achievement. Our theoretical framework for this research adopts a scientific inquiry-based approach. The scientific inquiry-based approach, according to the National Science Education Standards (NRC, 1996), the Benchmarks of Science Literacy (AAAS, 1994), International Society for Technology in Education, (ISTE, 2014), and Next Generation Science Standards (NGSS, 2013), is investigation driven and science process initiated. It also goes beyond the mere development of process skills such as observing, inferring, questioning, interpreting, and analyzing data. It combines these processes with scientific knowledge, scientific reasoning, and critical thinking to develop scientific knowledge (Lederman *et al*., 2014). Scientific inquiry will guide us in examining the nature of the data (Yao *et al*., 2008). By following the scientific inquiry, we will begin with an extensive exploration of the dataset (NAEP) and then design our data-based research questions to mine the data systematically since there is no single set of sequential steps to follow in the scientific inquiry (Lederman *et al*., 2014; Sandoval, 2005). The focus of the research is the goal of the data mining – the discovery of knowledge from data (Piatetsky-Shapiro, 1996). With the scientific inquiry-based approach and data mining focus, the authors established this theoretical framework for the present quantitative data mining research (Bond and Zhang, 2017).

Literature Review

Since the introduction of computers in the classroom, educational technology has been used to support the development of reading skills. Educational technology is defined as "a variety of electronic tools and applications that help deliver learning content and support the learning process" (Cheung and Slavin, 2013) and there have been several studies that have explored the relationship between computer use and reading achievement, many showing positive effects. Learning to read is a complex process that involves skills such as fluency, vocabulary, and comprehension, and successful readers develop these skills in the primary grades. Reading proficiency is key to future learning, and transitioning from "learning to read" to "reading to learn"can present challenges that technology-supported instruction can help to overcome. Students who cannot read well in the early grades have a greater risk of performing poorly in future grades (Cheung and Slavin, 2013), and students in upper elementary grades, particularly low-income students, often experience a slowdown in reading achievement due to increased exposure to less familiar vocabulary and more abstract ideas (Suhr *et al*., 2010). Suhr *et al*. (2010) found that laptop use over multiple years may have a positive effect on literacy outcomes for students in upper elementary grades, but Biancarosa and Griffiths (2012) suggested that technology alone won't address student needs – students must learn to use technology for more than drill and practice to acquire the literacy skills that will meet the changing demands of today's information landscape. The pervasiveness of technology in today's society presents early readers with many opportunities to develop their skills, and computers – at both school and home – can play an integral part in improving reading achievement. It is important to recognize that as access to computers and the Internet becomes more integrated into reading development, disparities in access can create a digital divide that should be addressed. Fairlieand Robinson (2013) pointed out that computer ownership alone may not influence short-term outcomes of low-income students, and the nature of computer use may determine the impact on educational achievement.

Reading, Technology and Socio-economicStatus

Given that a central purpose of American public education has been to provide access to education for all students, regardless of ability to pay, considerable research has been conducted to examine the relationship between students' socioeconomic status and academic achievement. White (1982) reported that socioeconomic status in educational research is defined as "the position that an individual or family occupies with reference to the prevailing average of standards of cultural possessions, effective income, material possessions, and participation in group activity in the community" (p. 462). Research studies have connected socioeconomic status to academic achievement, and Dotson (2014) reported that "in every state in the nation, the economically disadvantaged subgroup never outperforms other non-labeled students regardless of the grade level or subject area, supporting that the variable with the strongest correlation to academic achievement is socioeconomic status" (p. 25). Achievement differences based on socioeconomic status have been identified as early as kindergarten (Daily *et al*., 2011), and since low-income students are likely to attend lower quality schools, overcoming achievement gaps is unlikely without some form of intervention. Technology-supported instruction may be one such intervention, but Page's (2002) study of elementary students of low socioeconomic status found the most significant effects of increased access to technology was in mathematics, with no significant difference in reading scores. Additional research is needed to evaluate the effectiveness of technology in overcoming reading achievement gaps due to socioeconomic status.

Reading, Technology and Teachers

The impact of technology integration on student achievement is a key issue in today's education, and with increasing investment in school technology, it has become clear that "successful integration of computers into schools depends largely on how teachers embrace and use computers" (Fabry and Higgs, 1997). Teacher training plays an important role in empowering teachers to make decisions about technology, but professional development requires time and resources that many schools cannot provide. A 1997 study (completed just after the widespread introduction of computers in US schools) found that classroom computers "suffered from poor teacher training, high numbers of students trying to use the equipment, and poor software" (as cited in Parker and Davey, 2014). Lack of teacher training can also have a detrimental impact on teacher beliefs and attitudes, especially related to teachers' sense of self-efficacy. This may mean that even when schools provide computers, teachers underutilize them. Technologies that facilitate reading development should be based on effective instructional practices and support diverse learners. In order toeffectively integrate technology for reading development, teachers should have adequate training and support (Biancarosa and Griffiths, 2012).

While the relationship between teacher training and the impact of technology on student achievement is somewhat indirect, Securro, Mayo, and Rinehart (2009) pointed out that "it is the classroom teacher who creates a context for learning with related beliefs, perceptions and expectations that will set the stage for the successful implementation and use of technical instruction" (p. 78). Teacher technology training may thereforebe a key factor in helping teachers to develop the necessary skills and attitudes to make effective use of technology to improve student achievement. Hutchison and Reinking (2011) noted that information and communication technologies (ICTs) offer unique affordances for reading and writing that build upon traditional forms of communication. Failing to integrate technology into language arts instruction may, therefore, leave students unprepared for the requirements of 21st-century learning.

Reading and School Use of Computers

School use of computers has been argued to improve student learning by offering improved access to resources, individualized learning activities, effective use of time, and the ability to more easily monitor student progress. As computers have become more prevalent in K-12 classrooms, a variety of educational applications have been developed to enhance student learning, with varying results. McDermott and Gormley (2016) reported that proponents of technology integration claim that computer-assisted instruction can help to improve student engagement, increase academic achievement, advance reading fluency, and enrich writing ability. However, their study found that while digital resources made multimodal and participatory teaching easier, technology may also have distracted students and inhibited their understanding, analysis, and critical thinking. An international comparison of the impacts of computer usage on students' reading performance found that, across 15 countries, students' reading achievement did not show significant improvement with computer use in classes (Lai *et al*., 2006). Asserting that most studies find that classroom computers have minimal effect on academic achievement, Falck *et al*. (2015) considered the "opportunity cost" of computer-assisted instruction (the degree to which the time used for computer instruction replaces traditional use of teaching time). These authorsconcluded that "the overall null effect of using computers in schools is a combination of relatively productive and unproductive uses of computers" (Falck *et al*., 2015). While these results imply that the value of technology integration is uncertain, there are also a significant number of studies that demonstrate that school use of computers can have a positive effect on learning.

Kunkel's (2015) meta-analysis of 61 studies found that the mean effects for students receiving reading computer-aided instruction were small but positive when compared to students receiving no treatment or received non-reading computer-aidedinstruction. Dorris' (2014) study of Headsprout Early Reading, a technology-based program that provided core, supplemental, and/or remedial instruction in reading for students in Grades K-12, found that the use of a technology-supported reading program had positive effects on the reading achievement of elementary school students. A study by O 'Dwyer, Russell,Bebell, and Tucker-Seeley (2005) concluded that technology use, whether at school or at home, was significantly related to fourth grade performance on the Massachusetts Language Arts test, and furthermore, that different types of technology use affect achievement in different ways.

Reading and Home Use of Computers

The impact of home computer use on educational outcomes has become especially important as access to home computers has increased. Rosén and Gustafsson (2016) described studies that demonstrate both positive and negative effects of home computer use on academic achievement, suggesting that the lack of consistent results may be due to methodological challenges of measuring effects of home computer use from non-experimental data. Concerns about equity have prompted research to determine whether broadening access to home computers and the Internet is a worthwhile investment in terms of student achievement gains. One such study by Vigdor *et al*. (2014) found that home computer use is associated with modest negative impacts on student math and reading scores, and that expanded access to home computers and high-speed Internet might actually broaden, rather than narrow achievement gaps related to socio-economic status. Another study by Fairlieand Robinson (2013) found no evidence that home computers had an effect (either positive or negative) on any educational outcome. There is, however, some evidence that household media environment (televisions, DVD players, computers, Internet) is associated with student performance on standardized tests. According to Borzekowskiand Robinson (2005), having a home computer was associated with better academic performance, and students who reported more time using media also reported more time reading and doing homework. The authors also noted that home computers were found to increase communication between friends and family, contributing, perhaps, to students' language and literacy development. Just as the home literacy environment (number of books in the home, the age at which a child was first read to, and the amount of time that children spend reading with family members) contributes to students' reading comprehension (Katzir *et al*., 2009), the availability of technology in the home may also impact reading achievement. A number of studies have examined the relationship between computer use and reading achievement both in school and at home. Early

reading proficiency has a significant influence on a child's future educational, professional, and social success, but fourth grade reading achievement on the NAEP improved only slightly between 2003 and 2013 (Schneider *et al*., 2016). Gaining a better understanding of the influence of reading-related computer use on reading achievement will help identify ways to improve reading technologies and develop optimal practices for technology-supported reading and literacy instruction.

Methods

In order to gain a better understanding of the impact of reading-related computer use on the reading achievement of fourth grade students, this study used a quantitative descriptive research design to analyze secondary data extracted from the National Assessment of Educational Progress (NAEP) data set.

What is NAEP

The National Assessment of Educational Progress (NAEP), known as the Nation's Report Card, has been measuring student academic performance in mathematics, reading, science, history and the arts since 1969. Initially, assessments were given to a nationally representative sample of students from grades 4, 8, and 12, but since the federal No Child Left Behind Act of 2001, each state and jurisdiction has participated in the NAEP reading and mathematics tests at grades 4 and 8 every odd-numbered year. Results are reported at the national and state levels, with subgroup reports provided based on gender, race/ethnicity, disability status, limited English status, Title I status, school lunch status, and school size. The results are reported as both average scale scores and proficiency levels (Mueller Engheta, 2006). Because NAEP assessments use the same test booklets across the nation, with essentially the same questions from year to year, NAEP results serve as a common metric for all states and selected urban districts in the U.S., providing a clear picture of students' academic progress over time (Zhang and Li, 2009).

NAEP Background Questionnaires

In addition to assessing student achievement, NAEP also collects background information from students, teachers and schools in order to provide contextual information for the assessments and insights into factors that may be related to student learning. The results of these questionnaires can be analyzed using the online NAEP Data Explorer.

The questionnaires include:

- Student questionnaires – collect data on students' demographic characteristics, classroom experiences and educational support
- Teacher questionnaires – collect data on teacher training and instructional practices
- School questionnaires – gather information on school policies and characteristics

Data for the Present study

The present study used the NAEP Data Explorer (NCES, n.d.) to identify fourth grade reading proficiency scores and questionnaire items related to computer use for 2015, the most recent data available. The number of NAEP participants from across the country varies from grade to grade, subject to subject, and year to year, but approximately 6000 to 20,000 students per grade are assessed for each subject. Zhang and Li (2009) noted that over half of these students participate in the reading proficiency assessment.

Selection of Variables

The 2015 NAEP fourth-grade reading assessment composite average scale scores and standard deviations were selected for the analysis. Seven questions were chosen as variables for the present study, including two from the school questionnaire, three from the teacher questionnaire, and two from the student questionnaire. The questions were:

1. During this school year, about what percentage of students in your school was eligible to receive a free or reduced-price lunch through the National School Lunch Program? (school)
2. Are computers available for use by you or your students for reading/language arts instruction? (school)
3. During the past two years, have you received training from any source in the integration of computers and other technology into classroom instruction? (teacher)
4. Excluding preparation for class, how often do you use a computer or other technological resources in school for reading instruction/or reading activities? (teacher)
5. In your fourth grade reading/language arts class this year, how often do your students use a computer or other technological resources to build and practice vocabulary? (teacher)
6. Is there a computer at home that you use? (student)
7. Do you have access to Internet in your home? (student)

These variables were compared against the results of the reading proficiency assessment for 4th graders using the 2015 NAEP Data Explorer. Descriptive tables and tests of statistically significant differences were calculated by the Data Explorer. It is important to note that while NAEP data may have value as descriptive information, a causal relationship cannot be inferred from descriptive analyses (Creswell, 2015). The tests used in this study do not demonstrate a causal relationship since none of the data resulted from manipulation of the variables.

Findings and Analysis

In this section, the results of seven questions are presented, showing average scores and the percentage of different groups for each variable. The results of the NAEP Data Explorer tests for statistical significance are reported and analyzed as they relate to the points discussed in the literature review.

Reading, Technology and Socio-Economic status

The first variable to be analyzed is related to socioeconomic factors as indicated by eligibility for the National School Lunch Program. Schools reported average scores based on students who were eligible, not eligible, or eligibility information was not available. Education agencies and research communities use free and reduced lunch eligibility data as an indicator that household income falls below 130 % of the federal poverty level (Hoffman, 2012). While there is speculation about whether the use of lunch eligibility is a valid measure of socioeconomic status (Harwell and LeBeau, 2010),

it is used in this research as the best representation of this variable in the NAEP database.

Research Question #1

How are NAEP reading scores related to students' socio-economic status?

Table 1a.

Reading, grade 4 Difference in average scale scores between variables, for National School Lunch Program eligibility, 3 categories [SLUNCH3]National, 2015			
	Eligible (209)	Not eligible (237)	Information not available (236)
Eligible (209)		< Diff = -28 P-value = 0.0000 Family size = 3	< Diff = -27 P-value = 0.0000 Family size = 3
Not eligible (237)	> Diff = 28 P-value = 0.0000 Family size = 3		x Diff = 0 P-value = 0.7520 Family size = 3
Information not available (236)	> Diff = 27 P-value = 0.0000 Family size = 3	x Diff = 0 P-value = 0.7520 Family size = 3	
LEGEND:			
<	Significantly lower.		
>	Significantly higher.		
x	No significant difference.		
NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.			

Table 1b.

Reading, grade 4 Average scale scores for reading, grade 4 by National School Lunch Program eligibility, 3 categories [SLUNCH3], year and jurisdiction: 2015							
Year	Jurisdiction	Eligible Average scale score	Percentage	Not eligible Average scale score	Percentage	Information not available Average scale score	Percentage
2015	National	209	52%	237	42%	236	6%
NOTE: The NAEP Reading scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant. SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Reading Assessment.							

Table 2a.

Reading, grade 4 Difference in average scale scores between variables, for training in integrating computers into instruction in past two years [T097505] National, 2015			
	Already proficient (223)	Have not (220)	Yes (224)
Already proficient (223)		> Diff = 3 P-value = 0.0078 Family size = 3	x Diff = -1 P-value = 0.2099 Family size = 3
Have not (220)	< Diff = -3 P-value = 0.0078 Family size = 3		< Diff = -4 P-value = 0.0000 Family size = 3
Yes (224)	x Diff = 1 P-value = 0.2099 Family size = 3	> Diff = 4 P-value = 0.0000 Family size = 3	
LEGEND:			
<	Significantly lower.		
>	Significantly higher.		
x	No significant difference.		
NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.			

Table 2b.

Reading, grade 4 Average scale scores for reading, grade 4 by training in integrating computers into instruction in past two years [T097505], year and jurisdiction: 2015							
Year	Jurisdiction	Already proficient Average scale score	Percentage	Have not Average scale score	Percentage	Yes Average scale score	Percentage
2015	National	223	17%	220	21%	224	62%
NOTE: The NAEP Reading scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant. SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Reading Assessment.							

Of the schools that participated in the 2015 NAEP surveys, 52% of students were eligible for free or reduced lunches through the National School Lunch Program. Forty-two % were not eligible, and information was not available for 6% of students. The NAEP Data Explorer test for statistical significance between reading scores based on National School Lunch eligibility indicated that the group of 4th graders who were eligible for free or reduced lunches had significantly lower reading scores (28 fewer points) than the group of students who were not eligible for free or reduced lunches ($p < 0.5$). Assuming that eligibility for free or reduced lunches is representative of student socioeconomic status (SES), these results indicate that students with a lower SES score lower in reading than students with a higher SES. This finding is consistent with Reardon's (2013) assertion that "low-income students as a group have performed less well than high-income students on most measures of academic success—including standardized test scores" (p. 10).

Reading, Technology and Teachers

The second variable to be examined is related to teacher training in integrating computers into their instruction. Assuming that the integration of technology in schools positively influences student reading scores, this data may provide insight into the role of teacher training in facilitating technology integration, and the indirect relationship to academic achievement.

Of the teachers that participated in the 2015 NAEP surveys, 62% reported that they had received training in integrating computers into instruction in the past two years. Twenty-one percenthad not received training, and 17% reported that they were already proficient. It could thereforebe assumed that 79% of teachers had training or experience with integrating computers into instruction, and 21% lacked recent training. The NAEP Data Explorer test for statistical significance between reading scores based on teachers participation in training on integrating computers into instruction indicated that when teachers had received training in integrating computers into instruction in the past two years, 4th grade reading scores were significantly higher (four points) than when teachers had not received recent training ($p < 0.5$). When teachers were already proficient at integrating computers into instruction, 4th grade reading scores were also significantly higher (three points) than when teachers had not received training ($p < 0.5$). These results appear to support the suggestion that professional development is a key factor in teachers' ability to integrate technology into the curriculum (Bauer and Kenton, 2005; Hutchison and Reinking, 2011; Stolle, 2008). There was no significant difference in 4th grade reading scores between teachers who had received training and teachers who were already proficient. This may indicate that how recently teacher training occurred may not be significant.

Table 3a.

Reading, grade 4
Difference in average scale scores between variables, for computers available to teacher or students for reading or language arts [T105901] National, 2015

	Available to both (223)	Available only to teacher (221)	Not available (220)
Available to both (223)		> Diff = 2 P-value = 0.0047 Family size = 3	x Diff = 4 P-value = 0.1174 Family size = 3
Available only to teacher (221)	< Diff = -2 P-value = 0.0047 Family size = 3		x Diff = 1 P-value = 0.5661 Family size = 3
Not available (220)	< Diff = -4 P-value = 0.1174 Family size = 3	x Diff = -1 P-value = 0.5661 Family size = 3	

LEGEND:
< Significantly lower.
> Significantly higher.
x No significant difference.
NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.

Table 3b.

Reading, grade 4
Average scale scores for reading, grade 4 by computers available to teacher or students for reading or language arts, year and jurisdiction: 2015

Available to both		Available only to teacher		Not available	
88%		11%		1%	
M	SD	M	SD	M	SD
223	37	221	36	220	35

NOTE: The NAEP Reading scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant. SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Reading Assessment.

Research Question #2

How are NAEP reading scores related to teacher training in integrating computers into instruction in past two years?

Reading and School Use of Computers

To examine the relationship of NAEP reading scores to school use of computers, this research analyzed three variables: the

availability of computers for reading and language arts, use of computers for reading/instruction activities, and use of computers to build and practice vocabulary. The availability of computers, along with their use for reading/language arts-related activities, could influence fourth grade reading scores.

Research Question #3

How are NAEP reading scores related to reading-related school use of computers?

Eighty-eight %of schools reported that they make computers available to both teachers and students for reading or language arts. Eleven % made computers available only to teachers, and only 1% indicated that they did not make computers available to either teachers or students. The NAEP Data Explorer test for statistical significance between reading scores based on the availability of computers for reading and language arts indicated that there was no significant difference in 4th grade reading scores when computers were available to both teachers and students and when computers were not available ($p>0.5$). There was also no significant difference in scores when computers were available only to teachers compared to when computers were not available ($p>0.5$). The NAEP Data Explorer test for significance did show that 4th grade reading scores were significantly lower (two points) when computers were made available to the teacher only compared to when computers were available to both teachers and students ($p<0.5$). Overall, these results appear to conflict with Judge's (2005) finding of a positive relationship between the availability of computers in the classroom and students' academic achievement. It would be expected that access to computers for reading and language arts classrooms (especially when both teachers and students have access) would result in higher reading scores.

Table 3c.

Reading, grade 4 Effect sizes of differences in scores for reading, grade 4 by computers available to teacher or students for reading or language arts, year and jurisdiction: 2015

		Cohen's *d*	Result
Available to both	Available only to teacher	0.547	Medium
Available to both	Not available	0.833	Large
Available only to teacher	Not available	0.281	Small

Because the statistical significance findings were somewhat confounding, the researcher also calculated effect size for the computer availability variable. Using the Cohen's *d* calculation, a medium effect size (d=0.547) was identified in the difference between the mean average scale score of students when computers were available to both teachers and students and the mean when computers were only available to teachers. There was a large effect size (.833) in the difference between mean average scale scores of students when computers were available to both teachers and students and the mean when computers were only available to the teacher. There was a small effect size (.281) in the difference between mean average scale scores when computers were available only to the teacher and the mean when computers were not available at all. Overall, these results suggest that students are most successful when computers are available to both teachers and students, although students also score higher when computers are available only to teachers. Reading scores are lowest when students have no computer variable at all. The Cohen's *d* effect size correlated well with these findings except the scales of d did not correlate, probably due to sample sizes. These findings are consistent with O'Dwyer, Russell, Bebell, and Tucker-Seeley (2005), who found that when students reported greater school use of computers to edit papers, they were likely to have higher total English/language arts test scores. Fifty-six %of teachers reported that they use a computer for reading/instruction activities almost every day. Twenty-eight %reported using computers for this purpose once or twice per week, 10% do so once or twice per month, 4% do so a few times per year, and 2% reported that they never used a computer for reading/instruction activities. The NAEP Data Explorer test for statistical significance between reading scores based on the use of computers for reading/instruction activities indicated that scores for 4th graders whose teachers never use computers for reading instruction/activities are not significantly different from the scores of students whose teachers use computers with any other frequency ($p>0.5$). The scores of students whose teachers used computers for reading/instruction activities almost daily was significantly lower than scores for students whose teachers used computers once/twice per week, once/twice per month, and a few times per year ($p < 0.5$). This is not consistent with findings from Todtfeld's (2013) study that found that third grade students showed a significant gain in test scores after using the i-Ready computerized reading instruction program. These findings do, however, appear to support the observations of Vigdor, Ladd, and Martinez (2014), indicating that studies of the impact of instructional computer use in school settings have produced mixed results.

Only 16% of teachers reported that they use a computer with students to build and practice vocabulary almost every day. Thirty-five %reported doing so once or twice per week, 20% reported doing so once or twice per month, and 29% reported never using a computer with students to build and practice vocabulary. The NAEP Data Explorer test for statistical significance between the average scores based on student use of computers to build and practice vocabulary indicated that scores for 4th graders whose teachers never use computers build and practice vocabulary are not significantly different from the scores of students whose teachers use computers to build and practice vocabulary once/twice per week or once/twice per month ($p>0.5$). The scores of students whose teachers used computers to build and practice vocabulary almost every day was significantly different from scores for students whose teachers used computers once/twice per week or once/twice per month ($p<0.5$). The scores of students using computers to build and practice vocabulary almost every day was 6 points lower than scores of students who never or hardly ever used computers for this purpose. Scores of students using computers to build and practice vocabulary almost every day was 6 points lower than scores of students who used computers for vocabulary once or twice per month, and scores of students using computers to build and practice vocabulary every day or almost every day were 4 points lower than scores of students who used computers for vocabulary once or twice per week. Overall, the frequency of computer use for building and practicing vocabulary did not appear to have a positive influence on reading scores. This is somewhat consistent with findings from previous studies (Drummond *et al*., 2011; Kim *et al*., 2010), which did not find significant effects of computer-assisted reading instruction programs on reading vocabulary.

Table 4a.

Reading, grade 4
Difference in average scale scores between variables, for use computer for reading instruction/activities [T126401]National, 2015

	Never (221)	A few times a year (226)	Once or twice/month (226)	Once or twice/week (224)	Almost every day (222)
Never (221)		x Diff = -5 P-value = 0.1000 Family size = 10	x Diff = -5 P-value = 0.0445 Family size = 10	x Diff = -3 P-value = 0.1894 Family size = 10	x Diff = -1 P-value = 0.7994 Family size = 10
A few times a year (226)	x Diff = 5 P-value = 0.1000 Family size = 10		x Diff = -1 P-value = 0.5796 Family size = 10	x Diff = 1 P-value = 0.3723 Family size = 10	> Diff = 4 P-value = 0.0035 Family size = 10
Once or twice/month (226)	x Diff = 5 P-value = 0.0445 Family size = 10	x Diff = 1 P-value = 0.5796 Family size = 10		x Diff = 2 P-value = 0.0542 Family size = 10	> Diff = 5 P-value = 0.0000 Family size = 10
Once or twice/week (224)	x Diff = 3 P-value = 0.1894 Family size = 10	x Diff = -1 P-value = 0.3723 Family size = 10	x Diff = -2 P-value = 0.0542 Family size = 10		> Diff = 3 P-value = 0.0009 Family size = 10
Almost every day (222)	x Diff = 1 P-value = 0.7994 Family size = 10	< Diff = -4 P-value = 0.0035 Family size = 10	< Diff = -5 P-value = 0.0000 Family size = 10	< Diff = -3 P-value = 0.0009 Family size = 10	

LEGEND:
< Significantly lower.
> Significantly higher.
x No significant difference.
NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.

Table 4b.

Reading, grade 4
Average scale scores for reading, grade 4 by use computer for reading instruction/activities [T126401], year and jurisdiction: 2015

Year	Jurisdiction	Never Avg. scale score	%	A few times a year Avg. scale score	%	Once/ twice per month Avg. scale score	%	Once/ twice Per week Avg. scale score	%	Almost every day Avg. scale score	%
2015	National	221	2%	226	4%	226	10 %	224	28%	222	56 %

NOTE: The NAEP Reading scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant. SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Reading Assessment.

Table 5a.

Reading, grade 4
Difference in average scale scores between variables, for how often students use computer to build and practice vocabulary [T106001]National, 2015

	Never or hardly ever (225)	Once or twice a month (224)	Once or twice a week (223)	Every day or almost every day (219)
Never or hardly ever (225)		x Diff = 0 P-value = 0.8099 Family size = 6	x Diff = 2 P-value = 0.0342 Family size = 6	> Diff = 6 P-value = 0.0001 Family size = 6
Once or twice a month (224)	x Diff = 0 P-value = 0.8099 Family size = 6		x Diff = 1 P-value = 0.0892 Family size = 6	> Diff = 6 P-value = 0.0002 Family size = 6
Once or twice a week (223)	x Diff = -2 P-value = 0.0342 Family size = 6	x Diff = -1 P-value = 0.0892 Family size = 6		> Diff = 4 P-value = 0.0040 Family size = 6
Every day or almost every day (219)	< Diff = -6 P-value = 0.0001 Family size = 6	< Diff = -6 P-value = 0.0002 Family size = 6	< Diff = -4 P-value = 0.0040 Family size = 6	

LEGEND:
< Significantly lower.
> Significantly higher.
x No significant difference.
NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.

Table 5b.

Reading, grade 4
Average scale scores for reading, grade 4 by how often students use computer to build and practice vocabulary [T106001], year and jurisdiction: 2015

Year	Jurisdiction	Never/ hardly ever Average scale score	%	Once/twice per month Average scale score	%	Once/twice Per week Average scale score	%	Almost every day Average scale score	%
2015	National	225	29%	224	20%	223	35%	219	16%

NOTE: The NAEP Reading scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Reading Assessment.

Table 6a.

Reading, grade 4
Difference in average scale scores between variables, for computer at home [B017101] National, 2015

	Yes (225)	No (209)
Yes (225)		> Diff = 16 P-value = 0.0000
No (209)	< Diff = -16 P-value = 0.0000	

LEGEND:
< Significantly lower.
> Significantly higher.
x No significant difference.
NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.

Table 6b.

Reading, grade 4
Average scale scores for reading, grade 4 by computer at home [B017101], year and jurisdiction: 2015

Year	Jurisdiction	Yes Average scale score	Percentage	No Average scale score	Percentage
2015	National	225	83%	209	17%

NOTE: The NAEP Reading scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Reading Assessment.

Table 7a.

Reading, grade 4
Difference in average scale scores between variables, for at home have access to Internet [B0267A1]National, 2015

	Yes (227)	No (200)
Yes (227)		> Diff = 28 P-value = 0.0000
No (200)	< Diff = -28 P-value = 0.0000	

LEGEND:
< Significantly lower.
> Significantly higher.
x No significant difference.
NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.

Table 7b.

Reading, grade 4
Average scale scores for reading, grade 4 by at home have access to Internet [B0267A1], year and jurisdiction: 2015

Year	Jurisdiction	Yes Average scale score	Percentage	No Average scale score	Percentage
2015	National	227	83%	200	17%

NOTE: The NAEP Reading scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Reading Assessment.

Reading and Home Use of Computers

The final group of variables that were analyzed for this study were related to reading scores and the use of computers and internet at home. Vigdor, Ladd, and Martinez (2014) identified a number of quasi-experimental studies providing mixed evidence related to home computer access and student outcomes, but the following results demonstrate significant differences between scores of students who have access to computers and Internet at home and those who do not.

Research Question #4

How are NAEP reading scores related to using a computer at home?

Of the students that participated in the 2015 NAEP surveys, 83% of students indicated that they had a computer at home. Seventeen %of students reported that they did not have a computer at home. The NAEP Data Explorer test for statistical significance between the reading scores based on having a computer at home indicated that the group of 4th graders who did not have a computer at home had significantly lower reading scores (16 fewer points) than the group of students who did have a computer at home ($p < 0.5$). These results are consistent withHouse's (2007) finding that students who used a computer at home earned higher reading achievement test scores.

Research Question #5

How are NAEP reading scores related to at home access to the Internet?

Of the students that participated in the 2015 NAEP surveys, 83% of students indicated that they had Internet access at home. Seventeen %of students reported that they did not have Internet access at home. The NAEP Data Explorer test for statistical significance between reading scores based on having access to the Internet at home indicated that the group of 4th graders who did not have access at home had significantly lower reading scores (28 fewer points) than the group of students who did have a computer at home ($p < 0.5$). This finding is not consistent with the Vigdor, Ladd, and Martinez (2014) study that suggested that the introduction of broadband Internet access, along with computer ownership, could be detrimental for some students and not result in improved achievement in reading and math.

Summary of Findings

1. As indicated by eligibility in the National School Lunch Program, the average scale score of students of lower socioeconomic status was significantly lower (M=209, SD=.4) than students of higher socioeconomic status (M=237, SD=.3) by 28 points.
2. The average score of students when teachers had received training in integrating technology in the past two years was significantly higher ((M=224, SD=.5) than when teachers had not received training (M=220, SD=.7) by four points.
3. There was no significant difference in reading scores when computers were available to both teachers and students for reading and language arts and when no computers were available. Reading scores were significantly lower (two points) when computers were available to the teacher only (M=221, SD=.7) compared to when computers were available to both teachers and students (M=223, SD=.4). There was a large effect size (.833) in the difference between mean scores of students when computers were available to both teachers and students and when computers were only available to the teacher.
4. The average scale reading score of fourth grade students was:

    - Lower for students whose teachers used computers for reading/instruction activities almost daily than scores for students whose teachers used computers once/twice per week (3 points), once/twice per month (5 points), or a few times per year (4 points).
    - Lower for students using computers to build and practice vocabulary almost every day than scores of students who never or hardly ever used computers for this purpose (6 points), once or twice per month (6 points), or once or twice per week (4 points).

5. Students who reported that they did not have a computer at home (M=209, SD=.7) scored significantly lower than students who did have a computer at home (M=225, SD=.4) by 16 points.
6. Students who reported that they did not have Internet access at home (M=200, SD=.6) scored significantly lower than students who did have Internet access at home (M=227, SD=.3) by 28 points.

Although there does not appear to be a positive relationship between student reading scores and the frequency of computer use for reading-related classroom use, there does appear to be a positive relationship between student reading scores and computer use and Internet access at home. One possible explanation for the lack of significant difference in reading scores when computers are available to both teachers and students compared to when computers are not available may be tied to the fact that only 1% of schools reported that computers were not available. School use of computers may now be so pervasive that there is no longer a need to measure differences between schools that offer them and the very few who may not. There are still a significant number of students who do not have computer/Internet access at home, so the differences in reading scores between students that do report having these resources and those who do not is worth noting, especially since these results can be considered in conjunction with the somewhat mixed findings found in existing literature. The lower scores found for students who use computers almost daily for reading-related activities may indicate that frequent use of computers is detrimental to learning. Given that these findings are not consistent with the literature, further research is needed to determine if less frequent use of computers may result in higher scores.

Conclusions and Future Research

The purpose of this study was to explore the degree to which reading-related computer use influenced 2015 NAEP reading scores of fourth grade students, particularly those of lower socioeconomic status. The author used data from the online NAEP Data Explorer to analyze seven variables related to reading and student socioeconomic status, teacher training, and school and home use of computers. The results of the statistical

analyses may help to explain how selected variables are associated with 4th grade students' reading proficiency. These findings may be useful in helping elementary teachers and administrators understand the influence that technology may have on reading achievement. The results of this study indicate that the average scale scores of 4th grade students for reading are generally lower for students of lower socioeconomic status and for those who reported that they did not have computers or Internet access at home. These findings may indicate that concerns about inequity of technology resources across what is termed the "digital divide" are warranted. Sutton (1991) suggested that increased computer use in the 1980s exaggerated existing inequities in education rather than expanding educational opportunity. Lower scores for low-income students and those who have limited access to computers and Internet at home, as demonstrated by NAEP data from 2015, indicates that educational inequalities persist in spite of increased presence of technology in today's society. This study also demonstrated that teacher technology training has a positive relationship to academic achievement. Scores for students were higher when teachers had received training on integrating technology into the classroom in the past two years compared to when teachers had not received training. This appears to indicate that investments in teacher professional development related to technology integration may indirectly promote students' reading proficiency.

The results related to school use of computers were less clear. While 4th grade reading scores were higher when computers were available to both teachers and students compared to when computers were available to only teachers, no significant difference in scores was found when computers were available to both teachers and students and when computers were not available at all. Furthermore, this small difference in scores when computers were available to both teachers and students compared to when computers were available to teachers only may be attributable to teachers using computers for lesson preparation and administrative work rather than learning activities. Even so, this does not provide a reasonable explanation for the lack of difference between access and no access given that the literature provides some evidence that access to computers for reading and language arts results in higher test scores. The results related to teacher use of computers for reading instruction/activities are also inconclusive. Average scores for fourth graders whose teachers never used computers for reading instruction/activities were not significantly different from the scores of students whose teachers use computers a few times a year, once or twice per month, or once or twice per week. These results may be due, in part, to the generalized nature of the NAEP survey question. The concept of reading instruction/activities might include anything from a formal computer-assisted learning program to self-directed use of drill and practice applications or games. Given the lack of information about the nature of use, the effects of frequency of use on reading scores may not be representative.

Additional research into type of instructional use as well as frequency of use could provide results that are more meaningful. One surprising result from this analysis was that scores for students who used computers to build and practice vocabulary every day or almost every day were 4 points lower than scores of students who used computers for vocabulary practice with any other frequency. This result stands out because comparisons between scores showed no significant difference between students who used computers for vocabulary practice once or twice per month, or once or twice per week, or not at all. It is possible that daily computer-based vocabulary practice actually detracted from students' proficiency because of time taken away from traditional forms of instruction. This could be an example of the "opportunity cost" of computer-aided instruction described by Falck, Mang and Woessmann (2015), and further research could help teachers to better optimize instructional formats to benefit students. This study was based on the data from the online NAEP Data Explorer, but the variables measured were not comprehensive. Additional variables related to computer use and 4th grade reading proficiency could provide a clearer picture of the influence of technology-supported learning during this critical period in children's' reading development. Even so, the findings from this study may provide educators with a better understanding of the potential of technology integration for improving reading and literacy skills.

Based on the findings from the NAEP tests and literature review, recommendations for teachers and school administrators include:

1. Provide equitable access to computers for reading/language arts instruction in the classroom. School availability of computers may help to minimize the gap between students who have access to computers and the Internet at home and those who do not.
2. Support teachers' facility with integrating technology into reading/language arts instruction by offering timely professional development opportunities. Training can improve teacher knowledge and influence teacher attitudes, resulting in more effective use of technology and greater impact on student learning.
3. Monitor student achievement as it relates to frequency of computer-assisted learning, making adjustments as needed to strike an appropriate balance between computer-based instruction and traditional forms of instruction.

The growing presence of technology in every aspect of society requires ongoing attention to its influences, especially in educational contexts. The use of technology to support essential skills such as reading shows great potential, but the literature describes mixed results. Student success depends on early development of reading proficiency, and understanding the ways in which technology can help to bridge the achievement gap between students with lower socioeconomic status and students with higher socioeconomic status can help to "level the playing field" and enable all students to reach their potential. Making use of annual NAEP data offers an opportunity to examine student achievement at the national and state level, and monitor progress over time. Research into the impact of reading-related computer use could be expanded to include additional variables that can further assist teachers and school administrators in identifying ways to use technology to improve reading and literacy instruction.

REFERENCES

American Association for the Advancement of Science (AAAS). 1994. *Benchmarks for science literacy*. New York: Oxford University Press.

Bauer, J. and Kenton, J. 2005. Toward technology integration in the schools: Why it isn't happening. *Journal of Technology and Teacher Education, 13*(4), 519-546.

Biancarosa, G. and Griffiths, G. G. 2012. Technology tools to support reading in the digital age. *The Future of Children*, *22*(2), 139-160.

Bond, J. and Zhang, M. 2017. The Impact of Conversations on Fourth Grade Reading Performance - What NAEP Data Explorer Tells? *European Journal of Educational Research, 6*(4), 407-417. doi:10.12973/eu-jer.6.4.407

Borzekowski, D. L. and Robinson, T. N. 2005. The remote, the mouse, and the no. 2 pencil: The household media environment and academic achievement among third grade students. *Archives of Pediatrics and Adolescent Medicine*, *159*(7), 607-613.

Cheung, A. C. and Slavin, R. E. 2012. How features of educational technology applications affect student reading outcomes: A meta-analysis. *Educational Research Review*, *7*(3), 198-215.

Cheung, A. C. and Slavin, R. E. 2013. Effects of educational technology applications on reading outcomes for struggling readers: A best□evidence synthesis. *Reading Research Quarterly*, *48*(3), 277-299.

Child Trends Data Bank. 2015. *Home computer access and Internet use: Indicators on children and youth.* Retrieved from http://www.childtrends.org/indicators/home-computer - access/

Creswell, J. 2015. *Educational research: Planning, conducting, and evaluating quantitative and qualitative research.* Boston. Pearson.

Daily, S., Burkhauser, M. and Halle, T. 2011. School readiness practices in the United States. *National Civic Review*, *100*(4), 21-24.

Dorris, S. 2014. *The effects of computer-assisted instruction on the reading achievement of elementary school students* (Order No. 3629279).

Dotson, L. 2014. *Middle gradeacademic achievement and socioeconomic status on North Carolina state report cards, 2012-2013*. (Unpublished doctoral dissertation). East Tennessee State University, Johnson City, TN.

Drummond, K., Chinen, M., Duncan, T.G., Miller, H.R., Fryer, L., Zmach and Culp, K. 2011. *Impact of the Thinking Reader software program on grade 6 reading vocabulary, comprehension, strategies, and motivation: Final report* (NCEE 2010-4035). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Espinosa, L. M., Laffey, J. M., Whittaker, T. and Sheng, Y. 2006. Technology in the home and the achievement of young children: Findings from the early childhood longitudinal study. *Early Education and Development*, 17(3), 421-441.

Fabry, D. L. and Higgs, J. R. 1997. Barriers to the effective use of technology in education: Current status. *Journal of Educational Computing Research*, *17*(4), 385-395.

Fairlie, R. W. and Robinson, J. 2013. Experimental evidence on the effects of home computers on academic achievement among schoolchildren. *American Economic Journal: Applied Economics*, *5*(3), 211-240.

Falck, O., Mang, C. and Woessmann, L. 2015. *Virtually no effect? Different uses of classroom computers and their effect on student achievement.* Retrieved from https:// www.econstor.eu/bitstream/10419/108813/1/cesifo_wp526 6.pdf

Harwell, M. and LeBeau, B. 2010. Student eligibility for a free lunch as an SES measure in education research. *Educational Researcher*, *39*(2), 120-131.

Hoffman, L. 2012. *Free and reduced-price lunch eligibility data in Ed "Facts": A white paper on current status and potential changes.*Office of Planning, Evaluation and Policy Development, US Department of Education.

House, J. D. 2007. Relationships between computer use and reading achievement of elementary-school students: Results from the PIRLS 2001 assessment. *International Journal of Instructional Media*, *34*(4), 449-457.

Hutchison, A. and Reinking, D. 2011. Teachers' perceptions of integrating information and communication technologies into literacy instruction: A national survey in the United States. *Reading Research Quarterly, 46*(4), 312-333.

International Society for Technology in Education (ISTE). 2014. *ISTE standards: Teachers*. Retrieved from http:// www.iste.org/docs/pdfs/20-14_ISTE_Standards-T_PDF. pdf

Judge, S. 2005. The impact of computer technology on academic achievement of young African American children. *Journal of Research in Childhood Education*, *20*(2), 91-101.

Katzir, T., Lesaux, N. K. and Kim, Y. S. 2009. The role of reading self-concept and home literacy practices in fourth grade reading comprehension. *Reading and Writing*, *22*(3), 261-276.

Kim, J. S., Samson, J. F., Fitzgerald, R. and Hartry, A. 2010. A randomized experiment of a mixed-methods literacy intervention for struggling readers in grades 4–6: Effects on word reading efficiency, reading comprehension and vocabulary, and oral reading fluency. *Reading and Writing*, *23*(9), 1109-1129.

Kunkel, A. K. 2015. *The effects of computer-assisted instruction in reading: A meta-analysis* (Doctoral dissertation, University of Minnesota).

Lai, S. L., Chang, T. S. and Ye, R. 2006. Computer usage and reading in elementary schools: A cross-cultural study. *Journal of Educational Computing Research*, *34*(1), 47-66.

Lederman, J. S., Lederman, N. G., Bartos, S. A., Bartels, S. L., Meyer, A. A and Schwartz, R. S. 2014. Meaningful assessment of learners' understandings about scientific inquiry—The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching, 51*(1), 65-83.

Lederman, N. G., Antink, A. and Bartos, S. 2014. Nature of science, scientific inquiry, and socio-scientific issues arising from genetics: A pathway to developing a scientifically literate citizenry. *Science and Education*, *23*(2), 285-302

Malamud, O. and Pop-Eleches, C. 2011. Home computer use and the development of human capital. *The Quarterly Journal of Economics*, *126*(2), 987-1027.

McDermott, P. and Gormley, K. A. 2016. Teachers' use of technology in elementary reading lessons. *Reading Psychology*, *37*(1), 121-146.

Mueller Engheta, C. D. 2006. National Assessment of Educational Progress (NAEP). In *Encyclopedia of human development.* Thousand Oaks, CA: Sage Publications.

National Assessment of Educational Progress. (2004, February). *The nation's report card.* Retrieved from http://nces.ed.gov/nationsreportcard/

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.

NGSS Lead States. 2013. *Next generation science standards: For states, by states*. Washington, DC: National Academies Press.

O'Dwyer, L., Russell, M., Bebell, D. and Tucker-Seeley, K. R. 2005. Examining the relationship between home and school computer use and students' English/language arts test scores. *The Journal of Technology, Learning and Assessment*, *3*(3), 4-45.

Page, M. S. 2002. Technology-enriched classrooms: Effects on students of low socioeconomic status. *Journal of Research on Technology in Education*, *34*(4), 389-409.

Parker, K. R. and Davey, B. 2014. Computers in schools in the USA: A social history. In *Reflections on the History of Computers in Education* (pp. 203-211). Springer Berlin Heidelberg.

Piatetsky-Shapiro, G. 1996. *Advances in knowledge discovery and data mining* (Vol. 21). U. M. Fayyad, P. Smyth, and R. Uthurusamy (Eds.). Menlo Park: AAAI Press.

Reardon, S. F. 2013. The widening income achievement gap. *Educational Leadership*, *70*(8), 10-16.

Rosén, M. and Gustafsson, J. E. 2016. Is computer availability at home causally related to reading achievement in grade 4? A longitudinal difference in differences approach to IEA data from 1991 to 2006. *Large-scale Assessments in Education*, *4*(5), 1-19.

Schneider, D., Chambers, A., Mather, N., Bauschatz, R., Bauer, M. and Doan, L. 2016. The effects of an ICT-based reading intervention on students' achievement in grade two. *Reading Psychology*, *37*(5), 793-831.

Securro, S., Mayo, J. and Rinehart, L. 2009. Assessment of teacher beliefs and perceptions about the effects of computer-based technology on reading and language arts achievement. *Journal on School Educational Technology, 5*(1), 72-80.

Stolle, E. 2008. Teachers, literacy, and technology: Tensions, complexities, conceptualizations and practice. In *57th yearbook of the National Reading Conference* (pp. 56-69). Oak Creek, Wis, USA: National Reading Conference.

Suhr, K. A., Hernandez, D. A., Grimes, D. and Warschauer, M. 2010. Laptops and fourth grade literacy: Assisting the jump over the fourth-grade slump. *The Journal of Technology, Learning and Assessment*, *9*(5).

Sutton, R. E. 1991. Equity and computers in the schools: A decade of research. *Review of Educational Research*, *61*(4), 475-503.

Todtfeld, D. 2013. *The impact of instructional reading technology programs on student reading achievement*. (Unpublished doctoral dissertation). Northwest Missouri State University, Maryville, MO.

Vigdor, J. L., Ladd, H. F. and Martinez, E. 2014. Scaling the digital divide: Home computer technology and student achievement.*Economic Inquiry*, *52*(3), 1103-1119.

White, K. R. 1982. The relation between socioeconomic status and academic achievement. *Psychological Bulletin, 91*(3), 461.

Zhang, M. and Li, X.(2009. Exploring the relationship between non-school factors and NAEP reading scores. *STETS Language and Communication Review, 8*(1), 1-8.

****