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Computer Familiarity and Its Relationship to Performance in Three NAEP Digital-Based Assessments

AIR-NAEP Working Paper #01-2016

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Executive Summary

The National Assessment of Educational Progress (NAEP) program has been developing new digital-based assessments (DBAs) and plans to transition additional NAEP assessments from a paper-and-pencil administration to a technology-based assessment beginning in 2017. In light of these changes, it is important to consider how students' experience of using technology and technological devices may impact their performance on a technology-based assessment.

The current study aims to examine factor structures underlying NAEP student contextual questionnaire items designed to measure computer familiarity (as reflected by computer access and use measures). The study also aims to investigate how these computer familiarity factors relate to eighth-grade public school students' achievement in three recent NAEP DBAs: (1) the 2011 grade 8 Writing Computer-Based Assessment (WCBA), (2) the 2011 grade 8 Mathematics Computer-Based Study (MCBS), and (3) the 2013 grade 8 Technology and Engineering Literacy (TEL) pilot assessment.

Computer Access and Student Achievement Across Three Assessments

Across all three assessments, the results indicate that less than 7 percent of eighth-grade students in public schools across the nation lived in homes without a computer. However, more students who were eligible for the National School Lunch Program (NSLP) did not have a computer at home than did those who were not eligible. Similarly, more Black and Hispanic students than White students did not have computer access at home. No gender difference was identified in home computer access across the three assessments.

Home computer access was found to be positively related to student performance in all three DBAs. This relationship holds even after taking into account students' NSLP status, race/ethnicity, gender, and computer use. While there was a positive overall effect in the TEL pilot assessment, the effect functions differently for students who are NSLP eligible and for students who are not eligible. The achievement gap between those with and those without home computer access was wider for students who were not eligible for the NSLP than for students who were eligible.

Computer Use and Student Achievement in Three Assessments

Computer Use Factors

In each assessment, through factor analysis, we identified factors that reflect student computer use in the subject-matter domain. Below are descriptions of these factors in each assessment:

- 2011 grade 8 NAEP Writing Computer-Based Assessment (WCBA)
  - **Factor 1:** Captures students' use of the computer for school writing activities, including writing a first draft, making changes, completing their writing, getting information from the Internet, and writing school assignments.

- **Factor 2:** Captures students' use of the computer for general writing activities, including writing e-mails, writing using the Internet (e.g., for a blog or personal web page), and writing that is not a part of schoolwork.

- 2011 grade 8 NAEP Mathematics Computer-Based Study (MCBS)
  - **Factor 1:** Captures students' use of different types of mathematics-related computer programs at school.
  - **Factor 2:** Reflects students' general use of the computer for mathematics practice.
- 2013 grade 8 NAEP Technology and Engineering Literacy (TEL) pilot assessment
  - **Factor 1:** Captures students' specific computer use to create spreadsheets or presentations, both at school and outside of school.
  - **Factor 2:** Captures students' general use of the computer or other digital technology devices, both at and outside of school, including sending or receiving messages; creating, editing, or organizing digital media; and sending, sharing, presenting, or uploading digital media.
  - **Factor 3:** Captures students' self-efficacy at using the computer for some TEL-related activities.

Computer Use and Student Achievement in the WCBA

In the WCBA, female students, NSLP-noneligible students, and suburban students reported using the computer for school-related writing activities more often than did their counterparts (i.e., male students, NSLP-eligible students and city students, respectively), as did White students in comparison to Black and Hispanic students. Black and Hispanic students reported using the computer more often for general writing activities than did White students, as did city students in comparison to suburban, town, and rural students.

Computer use for both general writing activities and for school-related writing activities was positively associated with students' overall achievement in writing, but the magnitude of the relationship was more pronounced for school-related use, even after controlling for students' sociodemographic membership.

Computer Use and Student Achievement in the MCBS

In the MCBS, general computer use for mathematics practice was not related to students' overall mathematics achievement. However, the use of different types of specific mathematics-related computer programs was *negatively* related to students' mathematics achievement (that is, more frequent use of specific mathematics-related computer programs was associated with poorer performance on the MCBS). The finding of a negative relationship is consistent with research results from the 2012 Program for International Student Assessment (PISA) computer-based reading and mathematics assessments (Organization for Economic Cooperation and Development [OECD], 2015). A negative relationship was also found in several earlier assessments: the 2006 PISA mathematics literacy assessment (Ziya, Dogan, & Kelecioglu, 2010), the 2000 PISA science literacy assessment (Papanastasiou, Zembylas, & Vrasidas, 2003), and the 1995 Trends in International Mathematics and Science Study (TIMSS) in science

(Papanastasiou, 2002). One possible explanation for these results is that the frequent use of specific mathematics-related computer programs is associated with a remedial purpose.

Computer Use and Student Achievement in the TEL Pilot Assessment

In the TEL pilot assessment, inverted U-shape curvilinear relationships were identified between students' TEL achievement and the two factors that capture (1) computer use for spreadsheets or presentations; and (2) general computer use. For both computer use factors, students who reported using the computer and technology devices at medium frequency levels had the highest scores on TEL. One possible explanation is that daily use of a computer for certain activities may distract students and take time away from content domain learning.

Another interesting finding is that for the set of items that measure the frequency of creating spreadsheets or presentations using the computer, students who reported daily use had lower average achievement scores on the TEL assessment than those who reported never or hardly ever using the computer for this purpose. Among the students who reported creating spreadsheets and presentations at and outside of school every day, more NSLP-eligible students than NSLP-noneligible students chose this option. Their "daily use" responses raises a concern about a possible social desirability bias associated with the everyday response option, specifically for this set of items. This bias has also been suggested in the literature (Hedges, Konstantopoulos, & Thoreson, 2000).

Students' self-efficacy at using the computer for some TEL-related activities, the third factor, was found to be positively and linearly related to TEL achievement after controlling for students' sociodemographic membership.

An interaction effect was detected between students' home computer access and NSLP eligibility with respect to their TEL performance. Our findings show that among NSLP-noneligible students, those *without* computer access at home scored significantly lower than those *with* computer access. This indicates that the home computer access measure may capture additional aspects of the income component of socioeconomic status that are not fully captured by NSLP eligibility.

Comparing the 2011 Mathematics Computer-Based Assessment With the 2011 Mathematics Paper-and-Pencil Operational Assessment

We replicated our analyses of the MCBS with the 2011 NAEP mathematics paper-and-pencil operational assessment, which was the only comparable paper-and-pencil assessment administered by NAEP in 2011. The findings show that access to a computer at home and math-related computer use exhibited similar relationships with math performance in the paper-and-pencil test as in the MCBS and that the magnitude of the effects was also similar (see Appendix C for details). This suggests that the administration mode may not be the underlying factor that explains the patterns found between computer access and use and math performance in the MCBS.

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Background and Purpose

Technology and digital devices have become critical parts of 21st century life and play an increasingly large role in facilitating students' learning in classrooms, at school, and at home. Reflecting the impact of technology on current educational practices, the National Assessment of Educational Progress (NAEP) program has developed digital-based assessments (DBAs) in the areas of writing, mathematics, and technology and engineering literacy, with a plan to transition additional NAEP assessments from a paper-and-pencil assessment to a digitally based assessment that will be administered on a tablet computer beginning in 2017. Accordingly, it is important to consider how students' experience of using technology and technological devices may impact their performance on a digital-based assessment.

Literature Review

A number of published studies on academic achievement (e.g., Hedges, Konstantopoulos, & Thoreson, 2000; Mayes, 1992) have found that students' computer familiarity (e.g., the extent of their computer exposure and usage) is significantly related to their test performance in various academic areas, including English language arts (ELA), mathematics, and science. The relationships obtained were evidence either for some knowledge benefit that was gained through computer use or possibly some advantage due to higher socioeconomic status (SES), as reflected by having access to computers. Sometimes the relationship between computer use/familiarity and academic performance was negative, indicating some other kind of dynamic.

In ELA, previous studies have revealed that the extent of students' computer use and their attitudes toward computers are significantly associated with their assessment scores. For example, Horkay et al. (2006) conducted a study using nationally representative samples of eighth-graders from the 2002 NAEP writing test (a paper-and-pencil assessment) and a NAEP writing assessment (a DBA)[1] administered in 2002. The results suggest that students' computer familiarity was positively associated with their computer-based writing test scores even after controlling for their paper-based writing scores. In the study, computer familiarity was measured in terms of the extent to which students used computers for different purposes, including playing computer games; writing using a word processing program; making tables, charts, or graphs on the computer; using a computer to plan their writing; and using e-mail to communicate with others. In another research study, using 986 fourth-graders from 55 intact classrooms in nine school districts in Massachusetts, O'Dwyer et al. (2005) found that students' frequency of technology use at school to edit papers was positively correlated with their performance on the Massachusetts Comprehensive Assessment System English/Language Arts test (a paper-and-pencil test) after controlling for prior achievement and SES. However, students' recreational use of technology at home (e.g., use of the home computer for games, instant messaging, e-mailing, searching the Internet for fun, and music) was negatively related to their test outcomes. These results suggest that the relationship between computer familiarity and writing performance can be complex, yielding sometimes unexpected results.

[1] The NAEP Writing Online study is a special study that was administered in 2002 with samples drawn from the main NAEP assessment conducted in that year.

In mathematics, the effect of computer familiarity on student achievement also appears to be mixed. Evidence from several studies suggests that the effects of students' computer experience on their mathematics achievement, as measured by paper-and-pencil assessments, vary by the type or purpose of computer use. For instance, some studies on home computer use have found an overall positive relationship with students' mathematics achievement on paper-and-pencil assessments (e.g., House & Telese, 2012; Papanastasiou & Ferdig, 2006). In contrast, Ziya, Dogan, and Kelecioglu (2010) explored other purposes of computer use and students' mathematics achievement using data from the 2006 Program for International Student Assessment (PISA). Their findings indicated that using a word processor and computer programs to draw graphs, prepare presentations, and design web pages was negatively related to students' mathematics achievement. Using the Education Longitudinal Study of 2002 (ELS:2002) database, Flores, Inan, and Lin (2013) found that a higher frequency of computer use for lower level thinking skills, such as reviewing mathematics work or practicing mathematics drills, was negatively related to high school students' achievement on paper-and-pencil mathematics assessments.

Along with differences in achievement by various types or purposes of computer use, previous research findings suggest that the relationship between computer familiarity and mathematics achievement varies by grade level. For instance, Kim and Chang (2010a) studied the relationship between computer mathematics games and fourth-graders' achievement in mathematics using data from the 2005 NAEP mathematics assessment. Their results showed that fourth-grade male non-English language learners who played computer mathematics games every day at school had significantly lower mathematics achievement than their counterparts who played at the medium frequency level or never played. The authors explained that the beneficial effect of educational computer games may only be evident when students play these games at the optimal frequency level and suggested that further studies needed to be conducted to explore what that might be.

On the other hand, Bowers and Berland (2013), who studied high school students from the ELS:2002 database, reported a positive relationship between recreational computer use (as measured by the extent of using computers for fun and to play video games) and mathematics achievement, as measured by a paper-and-pencil assessment. In a study on a nationally representative sample of eighth-grade students from the 2001 NAEP Math Online (MOL) study, Bennett et al. (2008) measured the degree of students' computer familiarity through self-reports of computer experience and computerized measures of their typing accuracy and speed on the MOL test. The results suggest that students' input accuracy and speed are positively associated with their performance on the computer-based mathematics test after controlling for their performance on a paper-and-pencil mathematics test. Other studies suggest that the relationship between computer use and mathematics achievement may differ by demographic factors, such as gender, race/ethnicity, and SES (Cuban, 1993; Kim & Chang, 2010b; Kozma & Croninger, 1992).

In science, Papanastasiou (2002) studied data from the Third International Mathematics and Science Study (TIMSS) 1995 science assessment and found that the frequency with which students used computers in the classroom was negatively related to their science achievement in a number of countries, including the United States, Hong Kong, and Cyprus. Papanastasiou, Zembylas, and Vrasidas (2003) extended this study using data from the PISA 2000 science literacy assessment and found a negative correlation between the use of the computer to perform certain tasks and students' science achievement. For instance, after controlling for SES, they found that U.S. students who frequently used certain types of educational software (e.g., drawing, painting, or graphics software or spreadsheets) had lower science literacy scores than those students who used them less often.

To explore how computer use is related to adolescent problem-solving skills in the areas of technology and engineering, DeBoer (2012) used a propensity score technique to study the effects of student computer use on problem-solving outcomes within and between schools and across four countries (the United States, Canada, Korea, and Thailand) using data from PISA 2009. DeBoer's measures came from a set of questions on information and communication technology (ICT) in a student contextual questionnaire, as well as an assessment section on problem-solving skills. In the analysis, DeBoer limited her sample by focusing on the bottom quarter of families based on an economic and sociocultural status index ranking for each country. The results revealed that computer use at school was positively related to U.S. students' problem-solving skills, as measured by the PISA 2009 assessment. However, across the four countries studied, computer use at home had either no effect or a negative effect on students' problem-solving achievement. More specifically, computer use at home on a weekly basis for the purpose of searching for information on the Internet was negatively associated with students' problem-solving achievement. On the other hand, frequent use of the Internet to search for information at school appeared to be beneficial for students. The author recommended that research on more "effective" home computer use, such as increasing parent information on how they should direct their children on educational computer use, should be supported.

Besides the study from DeBoer, only a limited number of research studies have explored the relationship between students' knowledge and skills in technology and engineering and their computer familiarity.

In summary, the literature review indicates that studies that used NAEP data with a focus on eighth-grade students were conducted years ago and that students' achievement was measured through traditional paper-and-pencil tests. In some cases, the relationship between achievement and the extent of computer use for certain purposes was mixed.

As computers and technological devices have become prevalent both at schools and at home, it may be that the relationship between computer familiarity and achievement has changed; the relationship might also differ when the assessment is presented in a technology-based mode. It is therefore timely to investigate this issue using data from recent NAEP DBAs that cover different subject areas, prior to the planned transition of NAEP assessments to a technology-based platform starting in 2017.

Purpose of the Current Study

The current study aims to examine factor structures underlying NAEP student contextual questionnaire items designed to measure computer familiarity (as reflected by computer access and use measures) in order to see whether conceptually meaningful latent constructs emerge. Furthermore, the study aims to investigate how the computer familiarity factors relate to students' achievement on computer-delivered NAEP assessments in three subject areas: writing, mathematics, and technology and engineering literacy.

More specifically, the study addresses the following research questions for each NAEP digital-based assessment administered at grade 8:

Research Question 1: In each NAEP DBA, what is the factor structure underlying the computer-related variables from the NAEP contextual questionnaire? Can meaningful and reliable indices of computer familiarity be constructed from each assessment's contextual questionnaire?

Research Question 2: In each NAEP DBA, how does computer familiarity differ across sociodemographic groups, including race/ethnicity, gender, eligibility for the National School Lunch Program (NSLP), and/or urbanicity?

Research Question 3: To what extent is computer familiarity related to student achievement in each NAEP DBA?

Research Question 4: In each NAEP DBA, does the relationship between computer familiarity and academic performance vary across the selected sociodemographic groups?

Method

Data Sources

The three digital-based NAEP assessments investigated are the 2011 Writing Computer-Based Assessment (WCBA), the 2011 Mathematics Computer-Based Study (MCBS), and the 2013 Technology and Engineering Literacy (TEL) pilot assessment, each of which was administered at grade 8.[2] Except as noted, all of the analyses were limited to the national public school samples for purposes of comparability.[3]

2011 NAEP Writing Computer-Based Assessment

The NAEP Writing Computer-Based Assessment (WCBA) is the first fully fledged NAEP computer-based assessment developed under a new NAEP writing framework that recognizes the significant role that computers and technology play in the writing process and in students' daily lives. The WCBA was administered in 2011 to a nationally representative sample of 24,100 8th-grade students following standard NAEP sampling procedures.

The 2011 NAEP grade 8 WCBA consisted of a total of 22 writing tasks. However, each student was administered only two tasks. Students used laptop computers provided by NAEP with software similar to common word-processing programs to complete these tasks. Standard tools for editing, formatting, and viewing text were available on the laptop computers, and a handout was provided to each student to help them prepare their writing.

[2] The WCBA was also administered at grade 12. For purposes of comparability, only the grade 8 sample was used in the analyses.
[3] For the 2013 TEL pilot assessment, all analyses—except the exploratory factor analysis (EFA) and the confirmatory factor analysis (CFA)—were limited to the national public school sample. For the EFA and CFA, we used the nationally representative sample from both public and private schools.

The full sample of grade 8 public schools used in this analysis includes 22,090 students. The characteristics of the sample (before and after listwise deletion, both unweighted and weighted) are provided in Table 1. Since the percentage of students with missing data in at least one of the variables of interest (i.e., computer and sociodemographic group-related variables) was quite small (less than 3 percent), the decision was made to conduct complete case analyses (that is, students with one or more missing values were eliminated from the analyses). The complete case sample (CC sample) includes 21,480 public school students.

The comparison of the CC sample with the full reporting sample by major reporting groups[4] in Table 1 shows that the samples do not differ significantly in their distribution across subgroup characteristics. Thus, the CC sample is statistically representative of public school students in the nation.

[4] Parental education was not included as a major reporting group variable in the study because about 9 percent of students in the WCBA CC sample did not have information on parental education, and the missing parental education data are disproportionately concentrated in certain disadvantaged student groups, such as Hispanic students and students eligible for the NSLP. Deleting missing data on parental education in the WCBA would lead to an analysis sample that is not nationally representative of public school students.

Table 1. Composition of the NAEP Writing Computer-Based Assessment sample, by selected characteristics: 2011

Characteristics	Full reporting sample[1]			Complete case sample[1]		
	Weighted total	Weighted percent	Standard error	Weighted total	Weighted percent	Standard error
Total	3,335,889	100.0		3,250,426	100.0	
Gender						
Male	1,689,850	50.7	0.18	1,642,654	50.5	0.18
Female	1,646,039	49.3	0.18	1,607,773	49.5	0.18
Race/ethnicity[2]						
White	1,885,070	56.5	1.13	1,848,597	56.9	1.14
Black	494,663	14.8	0.83	473,973	14.6	0.81
Hispanic	708,656	21.2	1.09	684,280	21.1	1.11
Asian	161,599	4.8	0.39	159,182	4.9	0.39
NSLP eligibility						
Eligible	1,515,990	45.4	0.82	1,472,277	45.3	0.82
Not eligible	1,801,957	54.0	0.82	1,778,150	54.7	0.82
Information not available	17,942	0.5	0.22			

[1] The full reporting sample includes only students with assessment data, and the complete case sample consists of the students after listwise deletion.
[2] The race/ethnicity categories do not add up to 100 percent since American Indian/Native American students, Pacific Islander students, and students of two or more race are not reported here. The three racial groups are not used as subgroups in the study due to their small sample sizes.
Note: Detail may not sum to totals due to rounding. To test the difference between the full reporting sample and the complete case sample, *t* tests were conducted. None of the differences in the table are significant at the .05 level of significance.
Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2011 Writing Computer-Based Assessment.

2011 NAEP Mathematics Computer-Based Study

As the first trial of computer-based adaptive testing for NAEP, the Mathematics Computer-Based Study (MCBS) was conducted in 2011 among a nationally representative sample of eighth-grade public school students following standard NAEP sampling procedures.

One part of the MCBS was administered as a two-stage adaptive assessment. In the first stage, students were randomly assigned to one of two router blocks. In the second stage, students received one of three blocks that varied by difficulty: easy, medium, or hard. A total of 8,400 students participated in this study. For 3,340 students, the assignment of the second-stage block was determined by their performance on the router block at the first stage (called the “adaptive sample”). For the remaining 5,060 students (called the “calibration sample”), the second-stage block was randomly assigned, without regard to their performance on the router block. All analyses for this study used only the 5,060 students in the calibration sample.[5]

The characteristics of the full reporting calibration sample and the complete case calibration sample of the 2011 MCBS are compared with the national public sample from the 2011 NAEP

[5] As the administration of the adaptive sample of the MCBS was not comparable to the administration of the WCBA and TEL assessments, only the calibration sample of the MCBS was used for this study.

operational mathematics assessment in Table 2. As was true for the WCBA sample, only a small percentage of missing data (less than 5 percent) was identified in the variables of interest in the MCBS sample. Therefore, a complete case analysis was conducted with the MCBS calibration sample data, and about 3.5 percent of students were deleted due to missing data for the 12 variables related to computer access and familiarity and for the variable that reflects eligibility for the NSLP.

The CC sample includes 4,870 students from public schools. A comparison of the CC sample with the full reporting calibration sample by major reporting groups[6] shows that the CC sample is statistically representative of public school students in the nation (see Table 2).

Table 2. Composition of the NAEP Mathematics Computer-Based Study calibration sample and the national public school sample of the NAEP Grade 8 Mathematics Assessment, by selected characteristics: 2011

Characteristics	Full reporting calibration sample[1]			Complete case calibration sample[1]			National public school sample for the operational mathematics assessment (percent)
	Weighted total	Weighted percent	Standard error	Weighted total	Weighted percent	Standard error	
Total	3,242,988	100		3,130,934	100.0		100.0
Gender							
Male	1,636,606	50.5	0.53	1,585,015	50.6	0.55	50.7
Female	1,606,382	49.5	0.53	1,545,919	49.4	0.55	49.3
Race/ethnicity[2]							
White	1,779,603	54.9	2.05	1,741,756	55.6	2.03	53.7
Black	491,698	15.2	1.29	455,954	14.6	1.23	15.6
Hispanic	717,338	22.1	1.47	686,502	21.9	1.48	22.5
Asian	165,852	5.1	0.49	160,539	5.1	0.50	5.1
NSLP eligibility							
Eligible	1,494,488	46.1	1.77	1,429,419	45.7	1.78	47.7
Not eligible	1,722,693	53.1	1.85	1,701,515	54.3	1.78	51.9
Information not available	25,808	0.8	0.53				0.4

[1] The full reporting sample includes only students with assessment data, and the complete case sample consists of the students after listwise deletion.
[2] The race/ethnicity categories do not add up to 100 percent since American Indian/Native American students, Pacific Islander students, and students of two or more race are not reported here. The three racial groups are not used as subgroups in the study due to their small sample sizes.
Note: Detail may not sum to totals due to rounding. To test the difference between the full reporting sample and the complete case sample, *t* tests were conducted. None of the differences in the table are significant at the .05 level of significance.
Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2011 Mathematics Computer-Based Study.

[6] Parental education was not included in this study as a major reporting group variable because over 10 percent of students in the MCBS CC sample did not have information on parental education and the missing parental education data are disproportionately concentrated in certain disadvantaged student groups, such as Hispanic students and students eligible for the NSLP. Deleting missing data on parental education in the MCBS would lead to an analysis sample that is not nationally representative of public school students.

2013 NAEP Technology and Engineering Literacy Pilot Assessment

The NAEP Technology and Engineering Literacy (TEL) pilot assessment is the first national assessment of students' technology and engineering literacy. The assessment focuses on literacy in the knowledge and competencies that citizens need to function in a technological society. The TEL assessment is designed to measure three related areas of technology and engineering literacy: Technology and Society (TS), Design and Systems (DS), and Information and Communication Technology (ICT). According to the National Center for Education Statistics (2014):

- **Technology and Society** involves the effects that technology has on society and on the natural world and the ethical questions that arise from those effects.
- **Design and Systems** covers the nature of technology, the engineering design process by which technologies are developed, and basic principles of dealing with everyday technologies, including maintenance and troubleshooting.
- **Information and Communication Technology** includes computers and software learning tools, networking systems and protocols, hand-held digital devices, and other technologies for accessing, creating, and communicating information and for facilitating creative expression.

Unlike the WCBA and MCBS assessments, the TEL assessment uses an innovative item type—interactive and scenario-based tasks—in addition to short-answer and multiple-choice questions to measure students' knowledge and skills on the computer. Like the WCBA and MCBS, the TEL assessment is accompanied by a contextual questionnaire, the purpose of which is to understand students' opportunities to learn about technology and engineering, both inside and outside the classroom. The questionnaire includes questions on demographic characteristics as well as TEL-specific questions pertaining to students' experiences with technology.

The TEL pilot assessment was administered to a nationally representative sample of 16,320 eighth-graders in 2013. A full-scale TEL assessment was administered to eighth-grade students in early 2014. The current study uses the data from the 2013 TEL pilot assessment.

In the 2013 TEL pilot assessment, a matrix sampling method was used for the noncognitive items, which were administered to students in a 15-minute contextual questionnaire. A portion of the noncognitive items were taken by all students; the remaining items, including most of those that were computer related, were spiraled over 10 booklets. Thus, a substantial part of the data was "missing by design," and it was not feasible to conduct a complete case analysis using the full TEL sample. Instead, separate complete case analyses were conducted using two nationally representative subsamples. Detailed descriptions of the two subsamples can be found in the "Results" section of the report. The characteristics of the subsamples by major reporting groups[7] are presented in Tables 3a and 3b.

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[7] Parental education was not included in this study as a major reporting group variable because 9 to 10 percent of students in the two TEL CC subsamples did not have information on parental education and the missing parental education data are disproportionately concentrated in certain disadvantaged student groups, such as Hispanic students and students eligible for the NSLP. Deleting missing data on parental education in the TEL pilot would lead to an analysis sample that is not nationally representative of public school students.

Table 3a. Composition of the full reporting sample and the group 1 subsample of the TEL pilot assessment for grade 8 public school students: 2013

Characteristic	Full reporting sample[1]			Complete case analysis sample:[1] Group 1		
	Weighted total	Weighted percent	Standard error	Weighted total	Weighted percent	Standard error
Total	2,701,755	100.0		1,029,433	100.0	
Gender						
Male	1,379,547	51.1	0.22	530,871	51.6	0.35
Female	1,322,208	48.9	0.22	498,562	48.4	0.35
Race/ethnicity[2]						
White	1,498,663	55.5	1.40	571,362	55.5	2.26
Black	425,529	15.8	1.13	169,845	16.5	1.79
Hispanic	550,005	20.4	1.42	207,174	20.1	2.29
Asian	156,527	5.8	0.53	54,642	5.3	0.84
NSLP eligibility						
Eligible	1,275,227	47.2	1.01	475,181	46.2	1.61
Not eligible	1,387,586	51.4	1.01	554,251	53.8	1.61
Information not available	38,941	1.4	0.39			

[1] The full reporting sample includes only students with assessment data, and the complete case sample consists of the students after listwise deletion.
[2] The race/ethnicity categories do not add up to 100 percent since American Indian/Native American students, Pacific Islander students, and students of two or more race are not reported here. The three racial groups are not used as subgroups in the study due to their small sample sizes.
Note: Detail may not sum to totals due to rounding. To test the difference between the full reporting sample and the complete case sample, *t* tests were conducted. None of the differences in the table are significant at the .05 level of significance.
Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2013 Technology and Engineering Literacy Pilot Assessment.

Table 3b. Composition of the full reporting sample and the group 2 subsample of the TEL Pilot Assessment for grade 8 public school students, by selected characteristics: 2013

Characteristic	Full reporting sample[1]			Complete case analysis sample:[1] Group 2		
	Weighted total	Weighted percent	Standard error	Weighted total	Weighted percent	Standard error
Total	2,701,755	100.0		1,056,138	100.0	
Gender						
Male	1,379,547	51.1	0.22	539,747	51.1	0.35
Female	1,322,208	48.9	0.22	516,391	48.9	0.35
Race/ethnicity[2]						
White	1,498,663	55.5	1.40	579,542	54.9	2.22
Black	425,529	15.8	1.13	167,949	15.9	1.73
Hispanic	550,005	20.4	1.42	222,391	21.1	2.28
Asian	156,527	5.8	0.53	57,677	5.5	0.82
NSLP eligibility						
Eligible	1,275,227	47.2	1.01	504,267	47.7	1.58
Not eligible	1,387,586	51.4	1.01	551,871	52.3	1.58
Information not available	38,941	1.4	0.39			

[1] The full reporting sample includes only students with assessment data, and the complete case sample consists of the students after listwise deletion.
[2] The race/ethnicity categories do not add up to 100 percent since American Indian/Native American students, Pacific Islander students, and students of two or more races are not reported here. The three racial groups are not used as subgroups in the study due to their small sample sizes.
Note: Detail may not sum to totals due to rounding. To test the difference between the full reporting sample and the complete case sample, *t* tests were conducted. None of the differences in the table are significant at the .05 level of significance.
Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2013 Technology and Engineering Literacy Pilot Assessment.

Variables

The computer-related and student sociodemographic variables were drawn from the student contextual questionnaires for each of the three computer-based assessments. In each assessment, the outcome variables were the plausible values of the scale scores, which reflect overall student achievement. The five plausible values of the WCBA public school complete case sample are on a 0-to-300 scale, with a mean of 150 and a standard deviation of 35. The five plausible values of the MCBS public school complete case calibration sample are on a 0-to-500 scale, with a mean of 284 and a standard deviation of 36.

Scale score plausible values were not available on the TEL pilot assessment reporting scale. Therefore, the 20 TEL plausible values on the IRT theta scale (i.e., the mean is zero) were linearly transformed into the 0-to-300 NAEP reporting scale using the transformation coefficients from the WCBA grade 8 writing sample data. For the public school complete case sample, the mean of the TEL scale scores is 150 and the standard deviation is 35.

Analysis Procedures

To answer **research question 1**, we conducted exploratory and/or confirmatory factor analyses for each of the three DBA contextual questionnaires to determine whether meaningful factors of computer familiarity could be constructed for each instrument.

To address **research question 2**, we compared the computer access and familiarity variables across different sociodemographic groups in each assessment and used *t* tests to evaluate whether there were differences in access and use between a reference group and other groups. The purpose of these analyses was to examine whether certain groups may be disadvantaged with respect to their computer familiarity and access when compared with a reference group.

To address **research question 3**, we used multiple regression models to examine the relationship between computer familiarity indices and NAEP overall achievement, taking design effects into account. In each assessment, student achievement scores (five plausible values from the MCBS and the WCBA; 20 plausible values from the TEL assessment) were regressed onto the computer access and use variables, with the added control variables of student sociodemographic group membership.

To answer **research question 4**, two-way interaction variables were entered into the multiple regression models for each assessment to examine whether the relationships between computer familiarity and performance on the assessment vary in the selected sociodemographic groups. Design effects were taken into account.

Overall, three stages of multiple regression analysis were conducted for each assessment. At the first stage, computer familiarity and access variables were regressed on student overall achievement scores. At the second stage, group memberships (including race/ethnicity, gender, NSLP eligibility, and/or urbanicity[8]) were entered into the first-stage model, retaining statistically significant computer familiarity indices. At the third stage, two-way interactions between computer familiarity and student sociodemographic group membership were entered into the second-stage model, retaining previously entered variables with statistical significance.

For the MCBS and the WCBA, student weights (ORIGWT) were applied in all analyses. The jackknife method was used in variance estimation to address the complex survey design of NAEP. Adjusted effective degrees of freedom (Johnson and Rust 1993) were computed and were then used in all significance testing for these studies.

For the TEL pilot assessment, preliminary student weights (PSTUBWT) were applied to the analyses. Sample design variables were not available for the TEL pilot data; therefore, standard errors of the estimated parameters were estimated using design effects from comparable models in the analysis of the WCBA writing sample data. Furthermore, minimum adjusted effective degrees of freedom from a comparable model of the WCBA writing sample data were used to compute *p* values.

[8] The urbanicity variable is available in the WCBA and MCBS assessments, but not in the TEL pilot assessment.

Results

2011 NAEP Writing Computer-Based Assessment (WCBA) at Grade 8

Research Question 1: Factor Structure of the Computer-Related Variables

To answer research question 1, we explored the factor structure underlying the computer-related variables in the 2011 WCBA contextual questionnaire. Eight variables[9] were identified (see Table 4) and used for the exploratory factor analysis (EFA). The EFA used a polychoric correlation matrix to extract factors underlying the variables, given that the items used were ordered categorical variables. The Iterated Principal Factor Analysis (Principal Axis Factoring) method with oblique rotation was used, which allows factors to be correlated (Loehlin, 1992).

The factor analysis showed that a two-factor model appeared to best represent the data from the eight variables. The variable loadings on each factor were substantially larger than .40. While the eigenvalue of factor 2 was slightly below 1 (the conventional threshold for retention), we retained this factor because it made conceptual sense and the loadings for all three variables were sizable. Previous studies also suggest that overfactoring is preferable to underfactoring in EFA (Fabrigar et al., 1999).

Factor 1 contains five items that ask students about the frequency with which they use the computer to write school assignments (a report, essay, or letter),[10] write the first draft of a report, make changes to a report, look for information on the Internet for a report, and complete a report.[11] Therefore, this factor can be described as *using computer for school writing activities*.

Factor 2 contains three items[12] that ask students how often they use a computer for writing e-mails, writing using the Internet, and writing that is not a part of schoolwork. This factor is labeled as *using the computer for general writing*.

[9] All eight variables were considered to be ordered categorical variables.
[10] This item is on a 4-point Likert scale, with the response options of *never or hardly ever*, *once or twice a month*, *once or twice a week*, and *every day or almost every day*.
[11] These four items are on a 4-point Likert scale, with the response options of *never or hardly ever, sometimes, very often*, and *always or almost always*.
[12] These three items are on a 4-point Likert scale, with the response options of *never or hardly ever*, *once or twice a month*, *once or twice a week*, and *every day or almost every day*.

Table 4. Structure of the exploratory factor analysis of the computer use-related variables in the 2011 NAEP Writing Computer-Based Assessment

Variable	Factor 1 (using computer for school-related writing activities)	Factor 2 (using computer for general writing activities)
For school, how often use computer to make changes to a report	**0.88**	-0.06
For school, how often use computer to complete a report	**0.82**	-0.05
For school, how often use computer for a first draft	**0.71**	0.02
For school, how often use the Internet to get information	**0.70**	0.06
How often use computer to write school assignments	**0.50**	0.19
How often use computer to write e-mails	-0.01	**0.73**
How often use computer to write using Internet	0.03	**0.63**
How often use computer for writing other than schoolwork	0.05	**0.51**

Note: Factor loadings of .40 and above are marked in **bold**.

Factors 1 and 2 have a moderate correlation of .37. In addition, estimates of the internal consistency reliability of these two factors were obtained through the alpha statistic based on the polychoric correlation matrix (Gadermann, Guhn, & Zumbo, 2012). The reliability of indices is a function of both the number of items and their average intercorrelation. Cronbach's alpha (Cronbach, 1951), which is designed to estimate the reliability of continuous variables, would underestimate the reliability of the internal consistency of indices built from ordered categorical variables (Zumbo, Gadermann, & Zeisser, 2007; Gadermann, Guhn, & Zumbo, 2012).

The estimated reliability of factor 1 is .85, whereas the estimated reliability of factor 2 is .66. While the loadings of the three variables on factor 2 are acceptable by conventional standards, the reliability of this factor suffers because it consists of only three items.

Nonstandardized factor scores for each factor were computed with a sum of weighted measured variables that load on the factor (weighted by factor-scoring coefficients).

In addition, the item that asks "Is there a computer at home that you use?" did not load on either of the factors, but it is highly correlated with students' test performance and therefore was retained as a standalone variable.

All of these items—for computer access at home and for the variables underlying the two computer use factors—are detailed in Appendix B.

Research Question 2: Computer Familiarity Differences Across Various Sociodemographic Groups

To answer research question 2, which asks how computer familiarity differs across sociodemographic groups, we compared the two computer use factors and the home computer access item between each reference subgroup and other subgroups in selected sociodemographic groups defined by gender, race/ethnicity, NSLP eligibility, and urbanicity.

Home computer access

The results for home computer access are displayed in Table 5. Overall, for grade 8 students in public schools, computer access at home was high: 93.4 percent of students reported having a computer at home. Comparisons of home computer access across different sociodemographic groups show that:

- Lower percentages of Black students and Hispanic students (90.2 percent and 87.9 percent, respectively) than White students (95.9 percent) had a computer at home.
- A lower percentage of NSLP-eligible students (88.4 percent) than NSLP-noneligible students (97.5 percent) reported having computer access at home.
- A smaller percentage of students attending schools in cities had computer access at home than did their peers in suburbs, towns, or rural areas, with the differences ranging from 2 to 4 percentage points.
- No gender difference was detected in home computer access.

Table 5. Computer access at home for grade 8 students in the 2011 NAEP Writing Computer-Based Assessment, by selected characteristics

Characteristics	Weighted total	With computer at home		Difference between subgroups (percent)
		Percent	Standard error	
Total	3,250,426	93.4	0.22	
Gender				
Male	1,642,654	93.3	0.28	-0.2
Female	1,607,773	93.5	0.29	
Race				
White	1,848,597	95.9	0.26	
Black	473,973	90.2	0.43	-5.7 *
Hispanic	684,280	87.9	0.62	-8.0 *
Asian	159,182	97.9	0.53	2.0 *
NSLP eligibility				
Eligible	1,472,277	88.4	0.41	-9.2 *
Not eligible	1,778,150	97.5	0.20	
Urbanicity				
City	824,546	90.8	0.54	
Suburb	1,235,444	95.3	0.31	4.5 *
Town	402,214	93.0	0.83	2.2 *
Rural	788,222	93.3	0.45	2.5 *

Note: The difference between subgroups shows the difference in computer access at home between a subgroup and the reference group within a major reporting group. The female, White, not eligible for the NSLP, and city subgroups are the reference groups for the major reporting groups. An asterisk indicates that the difference is statistically significant at the .05 level.

Computer use factors

Results for the two computer use factors—*using computer for school writing activities* (factor 1) and *using computer for general writing* (factor 2)—are presented in Table 6. Scores for factor 1 range from 1.17 to 4.70 (with a mean of 3.2), and scores for factor 2 range from 1.08 to 4.66 (with a mean of 2.8). The results show the following:

- Male students used computers less often for writing than did female students, both at school and for other purposes, such as writing e-mails and writing using the Internet.
- Asian students used computers more often at school for writing-related activities and for general writing than did White students. Black and Hispanic students used computers less frequently at school for writing-related activities than did White students. However, Black students used the computer more frequently for general writing than did their White peers.
- Students eligible for the NSLP used computers less often for writing-related activities at school than did those who were not eligible. However, with respect to writing for general purposes, there was no difference in frequency of use between students who were eligible and not eligible for the NSLP.
- In terms of geographic location, city students used computers at school for writing-related activities less often than did students in suburbs. Nevertheless, city students used the computer more frequently for general writing purposes than did students in other geographic areas.

Overall, the results show that there are differences by gender, race/ethnicity, NSLP eligibility, and geographic location for the two computer use factors in the WCBA. However, since the differences in the scores are less than .40, they may not be substantively significant, even though they are statistically significant.

Table 6. Computer use indices for the 2011 NAEP Writing Computer-Based Assessment, by selected characteristics

Characteristics	Factor 1 (Using computer for school writing activities)			Factor 2 (using computer for general writing)		
	Mean	Standard error	Difference between subgroups	Mean	Standard error	Difference between subgroups
Total	3.2	0.01		2.8	0.01	
Gender						
Male	3.1	0.01	-0.2 *	2.6	0.01	-0.3 *
Female	3.3	0.01		3.0	0.01	
Race						
White	3.3	0.02		2.8	0.01	
Black	3.0	0.02	-0.2 *	2.9	0.01	0.1 *
Hispanic	2.9	0.02	-0.3 *	2.8	0.02	0.0
Asian	3.5	0.03	0.2 *	3.0	0.03	0.2 *
NSLP eligibility						
Eligible	2.9	0.01	-0.4 *	2.8	0.01	0.0
Not eligible	3.3	0.02		2.8	0.01	
Urbanicity						
City	3.1	0.03		2.9	0.01	
Suburb	3.3	0.02	0.2 *	2.8	0.01	-0.1 *
Town	3.1	0.05	0.0	2.8	0.03	-0.1 *
Rural	3.1	0.03	0.0	2.8	0.02	-0.1 *

Note: The difference between subgroups show the difference in computer use between a subgroup and the reference group within a major reporting group. The female, White, not eligible for the NSLP, and city subgroups are the reference groups for the major reporting groups. An asterisk indicates that the difference is statistically significant at the .05 level.

Research Questions 3 and 4: Computer Access, Computer Use, and Student Achievement in the WCBA

To examine research questions 3 and 4, a regression analysis was conducted to examine the extent to which computer access and computer use relate to student performance on the WCBA. Because computer access and use might be considered a proxy for SES, and confounded with sociodemographic membership, we examined whether the relationship between computer access and use and student performance held after controlling for membership in the major reporting sociodemographic groups: student NSLP eligibility, gender, race, and urbanicity.

In the regression analysis, the computer access at home item and the two computer use factors were first entered into a baseline model to test their relationships with students' performance on the WCBA. Next, gender, race/ethnicity, NSLP eligibility, and urbanicity were entered into the baseline model as control variables. Both sets of results—for the baseline model and the control model—are shown in Table 7.

The three computer-related variables were found to be significantly related to students' overall performance scores in the baseline model. The model's R^2 indicates that 15.5 percent of the variance in overall student achievement was explained by the three computer-related variables.

On average, students with computer access at home had a higher WCBA scale score (by 19.6 points) than did those without access, controlling for the two computer use factors. After controlling for the additional sociodemographic variables, the gap between students with and without computer access at home was still 12.3 points—about one-third of a standard deviation of the WCBA scale score.

For *using a computer for school writing activities*, every unit increase in frequency of computer use is associated with a 12.9-point increase in the WCBA scale. After controlling for additional sociodemographic variables, every frequency unit increase is still associated with an 8.9-point increase in the scale score (about one-fourth of a standard deviation of the WCBA scale score), indicating that the higher frequency of school-related writing on a computer is associated with better student performance on the WCBA.

For *using a computer for general writing*, every unit increase in computer use frequency is associated with only a 1-point increase in the WCBA scale score, after controlling for additional sociodemographic variables, suggesting that writing for general purposes on the computer may not be as beneficial as focused school-related writing on the computer.

Table 7. Regression models for the analysis of the 2011 NAEP Writing Computer-Based Assessment

Variables	Model 1 (baseline model)		Model 2 (with control variables)		Model 3 Final model	
	Estimate	Standard error	Estimate	Standard error	Estimate	Standard error
Intercept	108.0 *	1.14	138.1 *	1.49	133.4 *	1.78
Computer access						
No computer	-19.6 *	1.40	-12.3 *	1.39	-13.1 *	1.38
Using computer for school writing activities	12.9 *	0.38	8.9 *	0.37	10.5 *	0.50
Using computer for general writing	0.8 *	0.36	1.0 *	0.37	1.4 *	0.48
Gender						
Male			-17.6 *	0.45	-17.6 *	0.45
Race/ethnicity						
Black			-15.6 *	1.08	-12.3 *	2.24
Hispanic			-10.3 *	0.88	-6.5 *	1.95
Asian			4.6 *	1.82	3.4	3.97
Other			-2.2	1.71	0.1	4.40
NSLP eligibility						
Eligible			-15.7 *	0.85	-6.5 *	2.11
Urbanicity						
Suburb			4.2 *	1.16		
Town			-1.0	1.64		
Rural			0.6	1.34		
Using computer for school writing activities x NSLP eligibility						
Eligible for NSLP					-3.1 *	0.63
Using computer for general writing x Race/ethnicity						
Black					-1.0	0.72
Hispanic					-1.3 *	0.60
Asian					0.4	1.48
Other					-0.7	1.52
R squared	0.155		0.331		0.329	

Note: The having a computer at home, female, White, not eligible for the NSLP, and city subgroups are the reference groups. An asterisk indicates that the estimate is statistically significant at the .05 level.

Overall, the results from the baseline and control models indicate that computer access at home and the frequency of using computers for writing both at and outside of school are positively related to student performance on the WCBA. Furthermore, the magnitude of the relationship between computer use and student performance seems to be greater for school-related writing activities than for writing for general purposes. Since Black, Hispanic, and NSLP-eligible students use the computer more often for general writing than for school-related writing tasks, this may explain why, on average, they scored lower on the WCBA.

Previous research indicates that the relationship between computer use and student academic achievement may vary by students' sociodemographic characteristics. In the final model shown in Table 7, two-way interactions between computer-related variables and sociodemographic variables were tested. First, the regression results show a statistically significant interaction between NSLP eligibility and students' use of the computer for school writing activities. The negative coefficient suggests that the positive association between students' overall performance and their use of the computer for school writing activities was stronger for NSLP-noneligible students than for eligible students.

Since NAEP students are sampled from diverse schools, NSLP-noneligible students are likely to be from schools in which the teachers are competent in instructing students in the effective use of the computer for school writing activities. They are also likely to have well-educated parents who provide them with proper guidance in the effective use of the computer for writing. Thus, they may benefit more highly from more frequent use of the computer for school-related writing activities.

The results also reveal a significant interaction between Hispanic ethnicity and using the computer for general writing purposes. The interaction suggests that the experience of writing for general purposes helped White students slightly more than Hispanic students in their performance on the WCBA. Since about 18 percent of Hispanic students in the complete case sample were classified as English language learners, one possible explanation is that even though Hispanic students used the computer for general writing purposes more often than White students did, some Hispanic students may use the computer to write in their first language, rather than in English (and this may not contribute to higher performance on an English writing assessment, such as the WCBA).

Finally, note that the control model results show that the magnitude of the contribution of using the computer for general writing purposes in predicting students' WCBA score is small (about 1.0 point) after controlling for sociodemographic membership. Thus, the interaction may not be substantively significant, even though it is statistically significant.

2011 NAEP Mathematics Computer-Based Study (MCBS) at Grade 8

Research Question 1: Factor Structure of the Computer-Related Variables

For the MCBS data, we originally identified 14 computer-related items in the student contextual questionnaire. A screening of these items suggested eliminating three variables,[13] leaving 11 variables[14] in the EFA. The same EFA procedures used in the analysis of the WCBA data were applied to the MCBS.

The EFA conducted for research question 1 revealed two factors with an intercorrelation of .61. Items with loadings above .40 were included when building the factor indices. Although the eigenvalue of factor 2 was slightly below 1—similar to the results obtained in the WCBA analysis—we again decided to retain this factor because all of the component variables had substantial loadings on the factor and made conceptual sense. A brief description of each variable and the loading of each variable on the two factors are shown in Table 8.

[13] One item was excluded because of its cross-loadings on the two factors. The other two items do not load on either factor; these two items are correlated, but two variables are not sufficient to form a factor.
[14] Ten items are ordered categorical variables and one is a binary variable.

Factor 1 consists of eight items that measure the frequency of using different types of computer programs when doing mathematics for school:

- a statistical program to calculate patterns (such as correlations or cross-tabulations),
- a program to work with geometric shapes for mathematics classes,
- a graphing program to make charts or graphs for mathematics classes,
- a word processing program to write papers for mathematics classes,
- a program to practice or drill on mathematical facts,
- a spreadsheet program for mathematics class assignments,
- a program that presents new mathematics lessons with problems to solve, and
- a calculator program to solve or check problems for mathematics classes.

These items are on a 5-point Likert scale, with the response options of *never or hardly ever, once every few weeks, about once a week, two or three times a week,* and *every day or almost every day*. Factor 1 is best described as students' experience of *using computer programs for math*.

Factor 2 contains three items. These items measure

- whether students use a computer for math homework at home,
- on a typical day, how much time students spend doing work for mathematics class on a computer,[15] and
- the frequency of using a computer for math at school.[16]

Factor 2 is labeled *using computers for math in general*.

In addition, as in the analysis of the WCBA data, the item that asks "Is there a computer at home that you use?" was identified as a stand-alone variable that measures home computer access. The item does not load on either factor, but is related to MCBS performance.

All of these items—for computer access at home and for the variables underlying the two computer use factors—are detailed in Appendix B.

[15] This item is on a 5-point Likert scale, with the response options of *none*, *half an hour or less, about 1 hour, about 2 hours,* and *more than 2 hours*.
[16] This item is on a 5-point Likert scale, with the response options of *never or hardly ever*, *once every few weeks*, *about once a week*, *two or three times a week*, and *every day or almost every day*.

Table 8. Structure of the exploratory factor analysis of computer use-related variables in the 2011 NAEP MCBS calibration sample

Variables	Factor 1 (using computer programs for math)	Factor 2 (using computers for math in general)
When doing math, how often use statistical program	**0.91**	-0.05
When doing math, how often use program to work with geometric shapes for math class	**0.85**	0.00
When doing math, how often use graphing program for math class	**0.82**	0.03
When doing math, how often use word processing to write papers for math class	**0.78**	0.02
When doing math, how often use program to practice or drill on facts	**0.75**	0.06
When doing math, how often use spreadsheet program for assignments	**0.75**	-0.03
When doing math, how often use program that presents new math lessons	**0.75**	0.07
When doing math, how often use calculator program for math class	**0.54**	0.23
Do you use a computer for math homework at home	-0.06	**0.75**
Typical amount of time per day spent doing work for math class	0.06	**0.64**
How often do you use a computer for math at school	0.18	**0.45**

Note: Factor loadings of .40 and above are marked in **bold**.

To obtain estimates of the internal consistency reliability of each factor, we calculated the alpha statistic based on a polychoric correlation matrix. The estimated reliability of the index built for factor 1 is .93; for factor 2, it is .68. As in the WCBA analysis, the reason for the lower reliability of factor 2 is likely that it is based on only three items. Finally, factor scores were computed with the same procedure as were used for the WCBA.

Research Question 2: Computer Familiarity Differences Across Sociodemographic Groups

Home computer access

To examine research question 2, we examined computer familiarity within the various sociodemographic groups for each of the factors as well as the standalone variable: computer access at home. The results for computer access at home by sociodemographic groups are displayed in Table 9. Overall, as was true in the WBCA, computer access at home is high. Furthermore, the pattern of computer access observed in the MCBS is similar to that found in the WCBA:

- There was no gender difference in computer access.
- Lower percentages of Black and Hispanic students (88.2 percent and 87.3 percent, respectively) had computer access at home than did White and Asian students (95.4 percent and 97.0 percent, respectively).
- A higher percentage of NSLP-noneligible students (97.5 percent) than NSLP-eligible students (86.7 percent) had computer access at home.
- A higher percentage of students in suburbs (95.5 percent) reported having home computer access than did those in cities (89.7 percent).

Table 9. Computer access at home for grade 8 students in the 2011 NAEP Mathematics Computer-Based Study calibration sample, by selected characteristics

Characteristics	Weighted total	With computer at home		Difference between subgroups (percent)
		Percent	Standard error	
Total	3,130,934	92.6	0.48	
Gender				
Male	1,585,015	92.9	0.56	0.6
Female	1,545,919	92.2	0.56	
Race				
White	1,741,756	95.4	0.56	
Black	455,954	88.2	1.09	-7.2 *
Hispanic	686,502	87.3	1.20	-8.1 *
Asian	160,539	97.0	1.13	1.7
NSLP eligibility				
Eligible	1,429,419	86.7	0.75	-10.9 *
Not eligible	1,701,515	97.5	0.32	
Urbanicity				
City	746,188	89.7	0.97	
Suburb	1,326,362	95.5	0.61	5.8 *
Town	411,300	90.6	1.86	0.9
Rural	647,084	91.0	1.33	1.3

Note: The difference between subgroups show the difference in computer access at home between a subgroup and the reference group within a major reporting group. The female, White, not eligible for the NSLP, and city subgroups are the reference groups for the major reporting groups. An asterisk indicates that the difference is statistically significant at the .05 level.

Computer use factors

Results for the two computer use factors—*using computer programs for math* (factor 1) and *using computers for math in general* (factor 2)—are presented in Table 10. Scores for factor 1 range from 1.17 to 5.83 (with a mean of 1.86), and scores for factor 2 range from 1.08 to 4.51 (with a mean of 1.76).

- Male students used specific computer programs for mathematics at school more often than female students did, but there was no gender difference in general computer use.
- Black and Hispanic students used specific computer programs for mathematics at school more frequently than White students did, and they also exceeded their White peers in general computer use.
- NSLP-eligible students used computers for specific computer mathematics programs at school as well as for general mathematics work more frequently than did students who were not eligible.
- City students used computers more often than students from suburbs and rural areas for specific computer programs at school and for general mathematics work.

One cannot be certain why the frequency of use of specific computer programs for mathematics was relatively high for male students, Black and Hispanic students, NSLP-eligible students, and city students. However, since these student groups have lower mathematics achievement, on average, than their respective counterparts, this pattern may indicate that they use computer-related mathematical programs more frequently for remedial purposes.

Table 10. Computer use indices for the 2011 NAEP Mathematics Computer-Based Study calibration sample, by selected characteristics

Characteristics	Factor 1 (using computer programs for math) Mean	Standard error	Difference between subgroups	Factor 2 (using computers for math in general) Mean	Standard error	Difference between subgroups
Total	1.8	0.02		1.8	0.02	
Gender						
Male	1.9	0.03	0.1 *	1.8	0.02	0.0
Female	1.8	0.03		1.8	0.02	
Race						
White	1.7	0.02		1.7	0.02	
Black	2.2	0.05	0.5 *	1.9	0.04	0.3 *
Hispanic	2.0	0.03	0.3 *	1.8	0.02	0.1 *
Asian	1.8	0.08	0.1	1.9	0.06	0.2 *
NSLP eligibility						
Eligible	2.0	0.03	0.3 *	1.8	0.02	0.1 *
Not eligible	1.7	0.02		1.7	0.02	
Urbanicity						
City	2.0	0.03		1.8	0.02	
Suburb	1.8	0.03	-0.2 *	1.7	0.02	-0.1 *
Town	1.9	0.07	-0.1	1.9	0.07	0.1
Rural	1.8	0.05	-0.2 *	1.7	0.04	-0.1 *

Note: The difference between subgroups show the difference in computer use between a subgroup and the reference group within a major reporting group. The female, White, not eligible for the NSLP, and city subgroups are the reference groups for the major reporting groups. An asterisk indicates that the difference is statistically significant at the .05 level.

Research Questions 3 and 4: Computer Access, Computer Use, and Student Achievement in the MCBS

To examine research questions 3 and 4, we undertook a series of regression analyses parallel to those done in the WCBA analyses. The multiple regression results for the relationships between computer access and use and students' overall achievement in the MCBS are presented in Table 11. The results for the baseline model (model 1) show that computer access at home and the use of specific computer programs are related to students' overall performance on the MCBS, but not to the general use of computers for mathematics. On average, students with computer access at home scored 18.9 points higher on the MCBS score scale than did those without access, controlling for the two computer variables. After controlling for gender, race/ethnicity, NSLP eligibility, and urbanicity, model 2 shows that students with computer access at home still scored higher than those without home computer access by 9.2 points (about one-fourth of a standard deviation).

For *using computer programs for math*, the negative regression coefficient of the index indicates that students who used computer programs for mathematics more frequently had lower scores on the MCBS than those who used these programs less often, controlling for the other two computer variables. Every unit increase in the frequency of *using computer programs for math* is associated with a decrease of 12.5 scale score points. After controlling for home computer access, gender, race/ethnicity, NSLP eligibility, and urbanicity, the control model results still show that every unit increase in frequency is associated with a 9.9-point decrease (a little more than about one-fourth of a standard deviation) in overall student scores on the MCBS. As the literature review indicates, some previous studies (Papanastasiou, 2002; Papanastasiou, Zembylas, & Vrasidas, 2003; Ziya, Dogan, & Kelecioglu, 2010) using large-scale datasets, including TIMSS and PISA, also found a negative relationship between the use of computer programs and student achievement in mathematics and science, even though these assessments were administered in the paper-and-pencil mode.

One explanation for these counterintuitive findings might be that the students who reported using mathematical computer programs frequently are those who were in remedial mathematics programs due to low mathematics proficiency. Another explanation might be that the computer programs that eighth-grade students use for mathematics are not effective in promoting learning because they are not well tailored to their proficiency level. This issue is explored further in the "Summary and Discussion" section of this report.

Finally, to examine research question 4, we examined whether the relationships between the computer access and computer use variables and student achievement on the MCBS differed by sociodemographic group. The regression results show that there was no significant interaction between the computer-related variables and any subgroup membership. That is, the relationships between the computer familiarity variables and students' overall performance did not vary by subgroup. The results also confirmed that, on average, students who had computer access at home achieved higher scores on the MCBS than did those who did not have access. Furthermore, the results confirmed that students who used computer programs for mathematics more often had lower achievement scores on the MCBS than those who used computers less often for the same purposes. The final model (excluding the interactions that are not significant) is presented in Table 11.

Table 11. Regression models for the analysis of the 2011 NAEP Mathematics Computer-Based Study calibration sample

Variables	Model 1 (baseline model)		Model 2 (with control variables)		Model 3 (final model, without interactions)	
	Estimate	Standard error	Estimate	Standard error	Estimate	Standard error
Intercept	311.0 *	1.91	312.5 *	2.00	314.9 *	1.34
Computer access						
No computer	-18.9 *	2.18	-9.2 *	1.96	-9.6 *	1.95
Using computer programs for math	-12.5 *	0.85	-9.9 *	0.64	-9.9 *	0.64
Using computers for math in general	-0.7	1.19				
Gender						
Male			1.4	1.17		
Race/ethnicity						
Black			-15.5 *	1.97	-15.5 *	1.95
Hispanic			-9.2 *	1.62	-9.3 *	1.62
Asian			16.5 *	2.73	16.6 *	2.77
Other			-6.6	3.68	-6.6	3.72
NSLP eligibility						
Eligible			-15.1 *	1.37	-15.6 *	1.38
Urbanicity						
Suburb			3.1 *	1.73		
Town			1.0	2.50		
Rural			0.2	1.92		
R squared	0.128		0.249		0.247	

Note: The having a computer at home, female, White, not eligible for the NSLP, and city subgroups are the reference groups. An asterisk indicates that the estimate is statistically significant at the .05 level.

2013 NAEP Technology and Engineering Literacy (TEL) Pilot Assessment at Grade 8

Research Question 1: Factor Structure of the Computer-Related Variables

In the 2013 TEL pilot assessment, 14 contextual questionnaire items were identified as relevant to computer familiarity and used in the factor analysis. Because of the matrix sampling design, not all of the students who participated in the TEL pilot assessment were administered all 14 items. Due to the complexity of the data, both EFA and CFA procedures were employed to explore and extract factors from the data. A detailed description of the matrix sampling and the EFA and CFA procedures can be found in Appendix A of this report.

Overall, the EFA and CFA procedures showed that a three-factor model appeared to best represent the data from these 14 computer-related variables. Table 12 displays the structure of the final three-factor CFA model and factor correlations.

Factor 1 consists of six items that measure the frequency of using the computer or other digital technology, both at school and outside of school, to send or receive messages; create, edit, or organize digital media; and send, share, present, or upload digital media. These six items are on a

5-point Likert scale, with the response options of *never or hardly ever, a few times a year, once or twice a month, once or twice a week,* and *every day or almost every day*. We labeled this factor as *general computer use* (both at school and outside of school).

Factor 2 consists of four items that measure the frequency of creating spreadsheets or presentations, both at and outside of school. This factor is labeled as *computer use for spreadsheets or presentations*. The four items in factor 2 are on the same 5-point Likert scale as the other computer-related items.

Finally, factor 3 consists of four items that are related to students' self-efficacy for the following activities: publishing or maintaining a personal website or blog; creating presentations with sounds, pictures, or video; organizing information into a chart, graph, or spreadsheet; and comparing products using the Internet. The four items in factor 3 are on a 5-point Likert scale, with the response options of *I definitely can't, I probably can't, maybe, I probably can,* and *I definitely can*. We labeled factor 3 as *computer self-efficacy*.

Table 12. Structure of the confirmatory factor analysis of the computer use-related variables in the 2013 NAEP Technology and Engineering Literacy pilot assessment

Variables	Factor 1 (general computer use)	Factor 2 (computer use for spreadsheets/ presentations)	Factor 3 (computer self-efficacy)
Send or receive messages via pc	0.537	—	—
Create, edit, or organize digital media via pc	0.771	—	—
Send/share/present/upload digital media via pc	0.788	—	—
Send or receive messages out of school	0.520	—	—
Create/edit/organize digital media out of school	0.785	—	—
Send/share/present/upload digital media out of school	0.768	—	—
Create a spreadsheet via pc	—	0.656	—
Create a presentation via pc	—	0.686	—
Create a spreadsheet out of school	—	0.833	—
Create a presentation out of school	—	0.830	—
Able to publish or maintain a personal website or blog	—	—	0.678
Able to create presentations with sounds, pictures, or video	—	—	0.818
Able to organize information into a chart, graph, or spreadsheet	—	—	0.776
Able to compare products using the Internet	—	—	0.738
	Factor 1 (general computer use)	Factor 2 (computer use for spreadsheet/ presentation)	Factor 3 (computer self-efficacy)
Factor 1 (general computer use)	1.00		
Factor 2 (computer use for spreadsheets/presentations)	0.53	1.00	
Factor 3 (self-efficacy)	0.41	0.37	1.00

Note: The confirmatory factor analysis results are based on a sample size of 11,170. A dash means that the loading was fixed at zero.

The binary variable *Do you have computer access at home?* was not included in the factor analysis, but it was used as a stand-alone variable in the regression analysis (as in the analyses conducted for the WCBA and MCBS), as it is correlated with students' test performance on the TEL pilot assessment. All items for computer access at home and for the variables underlying the three computer use factors are detailed in Appendix B.

To check the reliability of each factor, an alpha statistic based on a polychoric correlation matrix was computed using complete cases. Listwise deletion was used to delete students with omitted responses when computing the factor scores. The alphas of the three factors from the complete cases ranged from .82 to .84. Since all of the variables used the same 5-point response scale, we computed the average raw scores for each respective factor from complete cases.

To maintain comparability with the analyses of the WCBA and MCBS sample data, the analysis was limited to public school students. Listwise deletion was then used to further eliminate students with missing data on gender, race/ethnicity, NSLP eligibility, and computer access at home (less than 5 percent of all students). The final public school student complete case sample consisted of about 9,900 students who were administered at least some of the 14 computer-related items.

Because the contextual questionnaire was missing data by design, and only a small number of students were administered all 14 of the computer-related items, it was challenging to conduct regression analyses with the complete case sample. In order to maximize the amount of information that could be obtained, two complete case subsamples were formed: the first subsample consists of about 5,600 public school students who received the 11 items that measure *home computer access*, *general computer use*, and *computer use for spreadsheets or presentations*. The second subsample consists of about 5,800 public school students who received the 5 items that measure *home computer access* and *computer self-efficacy*. These two complete case subsamples are not mutually exclusive,[17] but each is nationally representative of public school students in major NAEP reporting groups defined by gender, race/ethnicity, and NSLP eligibility. Sample distribution comparisons of these two subsamples are presented in the "Method" section of this report.

Research Question 2: Computer Familiarity Differences Across Sociodemographic Groups

Home computer access

All students in the full public school student complete case sample were administered the *home computer access* item. Table 13 presents comparison results of computer access by subgroups based on the full public school student complete case sample (*n* = 9,920). Overall, a high percentage of public school students (92.3 percent) indicated they have a computer at home they can use. We also found that:

- Lower percentages of Black students (88.5 percent) and Hispanic students (88.0 percent) reported having computer access at home than did White students (94.5 percent).
- A lower percentage of NSLP-eligible students (87.2 percent) reported having home computer access than did those who were not eligible (96.9 percent).
- No gender difference was identified in home computer access.

The findings for race/ethnicity, NSLP eligibility, and gender in the TEL pilot data are consistent with those from the MCBS and WCBA. Urbanicity information was not available in the TEL pilot data; therefore, no comparisons were made in terms of students' geographical locations.

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[17] All students in the final public school complete case sample were administered the *home computer access* item. Both subsamples contain about 1,600 students who were administered all 14 of the computer-related items.

Table 13. Computer access at home for grade 8 students in the 2013 NAEP Technology and Engineering Literacy pilot assessment, by selected characteristics

Characteristics	Weighted total	With computer at home		Difference between subgroups (percent)
		Percent	Standard error	
Total	1,817,150	92.3	0.36	
Gender				
Male	929,106	92.0	0.45	-0.5
Female	888,045	92.6	0.47	
Race/ethnicity				
White	999,504	94.5	0.42	
Black	294,755	88.5	0.66	-6.1 *
Hispanic	374,837	88.0	0.95	-6.5 *
Asian	99,788	98.5	0.62	4.0 *
NSLP eligibility				
Eligible	855,371	87.2	0.62	-9.7 *
Not eligible	961,780	96.9	0.32	

Note: The difference between subgroups shows the difference in computer access at home between a subgroup and the reference group within a major reporting group. The female, White, and not eligible for the NSLP subgroups are the reference groups for the three major reporting groups. An asterisk indicates that the difference is statistically significant at the .05 level.

Computer use factors

Table 14 displays the results of the three computer-related factors by subgroups. The scores of each factor range from 1.0 to 5.0. In terms of factor 1, *general computer use* (mean = 3.2), male students reported using computers or other digital technology devices less often than female students. Black students reported using computers or other digital technology more frequently than White students.

In terms of factor 2, *computer use for spreadsheets or presentations* (mean = 2.0), Black and Asian students made presentations or spreadsheets more frequently than White students. Compared with students who were not eligible for the NSLP, students who were NSLP eligible made presentations or spreadsheets more frequently.

With respect to factor 3, *computer self-efficacy* (mean = 3.8), the results show that male students reported lower self-efficacy in performing TEL-related tasks than female students. Hispanic students reported lower computer self-efficacy than White students, but there was no difference between White and Black students. Finally, students eligible for the NSLP reported lower computer self-efficacy than students who were not NSLP eligible.

Table 14. Computer use indices for the 2013 NAEP Technology and Engineering Literacy pilot assessment, by selected characteristics

Characteristics	Factor 1 (general computer use)			Factor 2 (computer use for spreadsheets or presentations)			Factor 3 (computer self-efficacy)		
	Mean	Standard error	Difference between subgroups	Mean	Standard error	Difference between subgroups	Mean	Standard error	Difference between subgroups
Total	3.2	0.03		2.0	0.02		3.8	0.02	
Gender									
Male	3.1	0.03	-0.3 *	2.0	0.02	0.0	3.8	0.03	-0.1 *
Female	3.4	0.03		2.0	0.02		3.9	0.03	
Race/ethnicity									
White	3.2	0.04		2.0	0.02		3.9	0.03	
Black	3.4	0.05	0.1 *	2.2	0.03	0.2 *	3.8	0.04	-0.1
Hispanic	3.2	0.05	0.0	2.0	0.03	0.1	3.6	0.04	-0.3 *
Asian	3.2	0.07	0.0	2.2	0.05	0.2 *	4.0	0.06	0.1
NSLP eligibility									
Eligible	3.2	0.03	0.0	2.1	0.02	0.1 *	3.7	0.03	-0.3 *
Not eligible	3.2	0.04		2.0	0.02		4.0	0.03	

Note: The difference between subgroups shows the difference in computer use between a subgroup and the reference group within a major reporting group. The female, White and not eligible for the NSLP subgroups are the reference groups for the three major reporting groups. An asterisk indicates that the difference is statistically significant at the .05 level.

Research Questions 3 and 4: Computer Access, Computer Use, and Students' Achievement in the TEL Pilot Assessment

To assess research questions 3 and 4, we conducted regression analyses with respect to the relationships between TEL achievement and the computer access and use variables. The results are displayed in Tables 15 and 16. Table 15 displays the regression results with respect to the *home computer access* variable and the variables for *general computer use* and *computer use for spreadsheets or presentations*. The analysis is based on the group 1 complete case public school subsample.

Before regression analysis, we conducted data exploration (e.g., bivariate scatterplots) to examine relationships between each computer use factor and the outcome variable (NAEP plausible values). In the TEL pilot data, inverted U-shape curvilinear relationships were found between *general computer use*, *computer use for spreadsheets or presentations*, and the TEL plausible values. Polynomial regression models were therefore fit to the data to reflect the nonlinear relationships.

In the baseline model (model 1), in addition to *computer access*, the linear terms (the first-order polynomials) and higher order terms (including the quadratic, cubic, and quartic) of *general computer use* and *computer use for spreadsheets or presentations* were entered into the model to test their statistical significance. The results indicate that both linear and quadratic terms are significant for these two computer use factors after controlling for the *computer access* variable. Altogether, the *computer access* variable, and the linear and quadratic terms of the two computer use factors, explained 7.3 percent of the variance in students' achievement scores on the TEL pilot assessment.

Next, student gender, race/ethnicity, and NSLP eligibility were added to the original model. The results are presented in model 2 of Table 15 and indicate that students with computer access at home had higher scores than those without home computer access (by 13.3 points, or about two-fifths of a standard deviation of the TEL scale score), controlling for all other predictors. In addition, model 2 shows that the linear and quadratic terms of *general computer use* are significant, confirming an inverted U-shape curvilinear relationship between the frequency of *general computer use* and students' overall TEL scores. In other words, when students' general computer use frequency is at a medium level (when the factor scores are between 3 and 4), their overall TEL scores are higher than the scores of those who use computers less frequently (e.g., never or hardly ever) as well as the scores of those who use computers more frequently (e.g., on a daily basis). In spite of this, students who reported using the computer for TEL-related activities on a daily basis still had higher overall TEL scores than those who reported never or hardly ever doing so.

In model 2, the linear and quadratic terms of *computer use for spreadsheets or presentations* are also significant after controlling for all other predictors. However, the inverted U-shape pattern is a little different from that for *general computer use*. Students who reported creating spreadsheets or presentations at a medium frequency level (when the factor scores are between 2 and 3) had the highest average scores; however, students who reported creating spreadsheets or presentations on a daily basis had lower TEL overall scores than those who reported never or hardly ever doing so. One possible explanation for these counterintuitive results is that frequent use of the computer or other technology devices may distract students. When students spend too much time doing certain activities—for example, creating spreadsheets or presentations—they may not have enough time left to gain and absorb more TEL-related knowledge through other sources, such as television, newspapers, books, and talking with parents or peers.

The counterintuitive pattern also suggests a potential validity problem with the response categories of the computer use items. The validity of "every day" as a response for creating spreadsheets or presentations is especially questionable, as our results show that a higher percentage of NSLP-eligible and minority (Black and Hispanic) students reported a high frequency of making spreadsheets or presentations than did NSLP-noneligible and White students. This issue is explored further in the "Summary and Discussion" section of this report.

Finally, to examine research question 4, we tested two-way interactions between the home computer access variable, the variables for general computer use and computer use for spreadsheets or presentations, and student sociodemographic groups. The results are presented in model 3 of Table 15 and show a significant interaction effect between computer access and NSLP eligibility status after controlling for computer variables and gender, race/ethnicity, and NSLP eligibility. As illustrated in Figure 1, the interaction first confirms that, on average, students with home computer access outperformed their peers without home computer access. However, figure 1 also illustrates that among NSLP-noneligible students, those without computer access at home scored significantly lower than those with computer access (and that the achievement gap between students with and without home computer access was larger for NSLP-noneligible students than for eligible students).

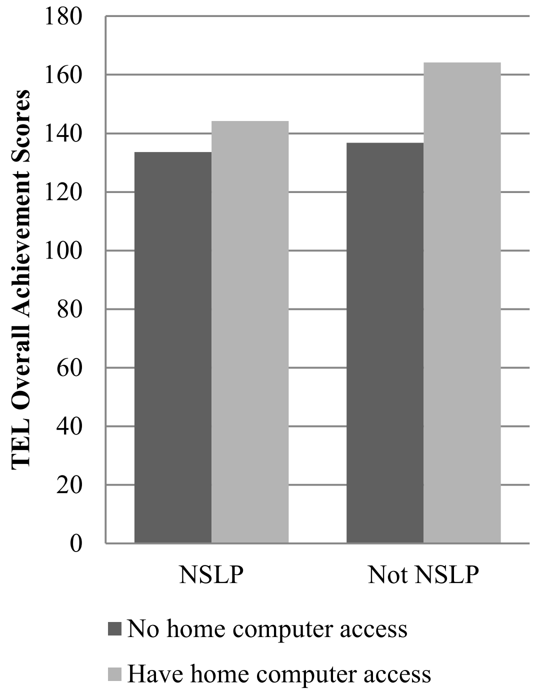
Despite the fact that NSLP eligibility can serve as a useful indicator of students' SES, it is not necessarily the best measure (Bass, 2010; Snyder & Musu-Gillette, 2015). Our results suggest that, in this case, the home computer access measure may capture additional aspects of SES that are not fully captured by NSLP eligibility. Furthermore, the results suggest that research should be conducted to explore the family characteristics of those students who were not from a low-SES background, but who had no computer at home. Family values about technology and engineering may also impact these students' achievement in TEL.

Table 15. Regression models for the analysis of the 2013 NAEP Technology and Engineering Literacy pilot assessment: Group 1

	Model 1 (baseline model)		Model 2 (with control variables)		Model 3 (with interactions)	
Variables	**Estimate**	**Standard error**	**Estimate**	**Standard error**	**Estimate**	**Standard error**
Intercept	100.7 *	6.05	126.8 *	6.62	127.6 *	6.88
Computer access						
No computer	-23.3 *	2.13	-13.3 *	2.14	-25.7 *	4.86
General computer use						
Linear	19.6 *	3.50	14.3 *	3.22	14.1 *	3.30
Quadratic	-2.9 *	0.54	-2.0 *	0.49	-2.0 *	0.50
Computer use for spreadsheets or presentations						
Linear	21.0 *	3.28	16.8 *	3.35	16.7 *	3.49
Quadratic	-4.7 *	0.65	-3.6 *	0.66	-3.6 *	0.69
Gender						
Male			-2.7 *	0.96	-2.7 *	0.97
Race/ethnicity						
Black			-20.9 *	1.92	-20.8 *	1.44
Hispanic			-14.1 *	1.78	-14.0 *	1.34
Asian			4.1	4.07	4.1	2.34
Other			-2.5	4.26	-2.5	3.30
NSLP eligibility						
Eligible			-18.4 *	1.74	-19.3 *	1.27
Computer access x NSLP eligibility						
No computer, eligible for NSLP					16.0 *	5.45
R squared	0.073		0.253		0.256	

Note: The having a computer at home, female, White, and not eligible for the NSLP subgroups are the reference groups for the four major reporting groups. An asterisk indicates that the estimate is statistically significant at the .05 level.

Figure 1. Regression interaction effect between home computer access and NSLP eligibility in the 2013 NAEP Technology and Engineering Literacy pilot assessment: Group 1



The results for factor 3, *computer self-efficacy,* are presented in Table 16. The analysis is based on the TEL pilot assessment group 2 complete case public school subsample. An exploration of the data shows that the relationship between computer self-efficacy and TEL plausible values is linear. Therefore, linear multiple regression models were fit to the data.

The regression results show that students' computer access at home and computer self-efficacy can predict students' overall TEL achievement scores. These two variables accounted for about 16 percent of the variance in TEL achievement scores. The baseline model (model 1) shows that students with computer access at home scored about 15 points higher on the TEL pilot assessment than did those without access, controlling for students' computer self-efficacy. Students' self-efficacy in TEL-related activities was positively associated with their TEL performance, and every unit increase in student self-efficacy is associated with a 14.4-point increase in the overall TEL scale score. After controlling for students' background variables, the increase in the TEL scale score is still about 12 points per unit increase in self-efficacy.

For the group 2 subsample, after controlling for gender, race/ethnicity, and NSLP status and including the interactions in model 3, the only significant interaction was between computer access and NSLP status. This interaction again confirms that the achievement gap between students with and without home computer access is greater for those who were not eligible for the NSLP (15 points) than for those who were eligible (5 points), after controlling for students' background variables.

Table 16. Regression models for the analysis of the 2013 NAEP Technology and Engineering Literacy pilot assessment: Group 2

Variables	Model 1 (baseline model) Estimate		Model 1 Standard error	Model 2 (with control variables) Estimate		Model 2 Standard error	Model 3 (with interactions) Estimate		Model 3 Standard error
Intercept	95.4	*	2.61	119.1	*	2.99	119.3	*	3.12
Computer access									
No computer	-14.8	*	2.00	-7.0	*	1.95	-15.2	*	4.32
Computer self-efficacy	14.4	*	0.67	12.1	*	0.61	12.1	*	0.63
Gender									
Male				-2.2	*	0.90	-2.2	*	0.91
Race/ethnicity									
Black				-23.7	*	1.84	-23.7	*	1.38
Hispanic				-13.3	*	1.61	-13.2	*	1.21
Asian				1.3		4.04	1.3		2.32
Other				-3.4		3.60	-3.5		2.77
NSLP eligibility									
Eligible				-16.0	*	1.79	-16.6	*	1.32
Computer access x NSLP eligibility									
No computer, eligible for NSLP							10.8	*	4.83
R squared	0.155			0.323			0.324		

Note: The having a computer at home, female, White, and not eligible for the NSLP are the reference groups for the major reporting groups. An asterisk indicates that the difference is statistically significant at the .05 level.

In general, the results from both subsamples suggest that lack of home computer access is negatively associated with student achievement on the TEL pilot assessment. Students' use of computers and other technology devices for various purposes is related to their overall performance, but the relationships are not linear. Students benefited the most from computers and other technology devices when they used them at the medium frequency level. The evidence indicates that students who used these devices daily had lower achievement on the TEL assessment than students who used these devices less often.

Summary and Discussion

In this study, we examined the extent to which public school students are exposed to computers and how they use computers and technology devices in three different subject areas: writing, mathematics, and technology and engineering literacy. In each subject area, we focused on how computer access and use are related to student performance on a computer-based NAEP assessment and whether the relationships between computer access and use and student performance vary by subgroups and other important student characteristics.

Home Computer Access and Student Test Performance

Overall, across the three computer-based assessments, more than 92 percent of eighth-grade students in public schools across the nation reported having a computer at home. However, lower percentages of Black and Hispanic students reported having computer access at home than did

White students, although the differences were not very large. In contrast, data from the three assessments collectively show that more than 86 percent of NSLP-eligible students reported having a computer at home, compared to more than 96 percent of NSLP-noneligible students. A lower percentage of students in cities had computer access at home than did their peers in suburbs, towns, and rural areas. No gender difference was identified in home computer access across the three assessments.

Across the three computer-based assessments, home computer access was positively related to student performance. The positive relationship holds even after taking into account student computer use, NSLP status, ethnicity, and gender. However, in the TEL pilot assessment, not having a computer at home seemed to have a differential effect on NSLP-eligible and noneligible students. That is, the achievement gap between those students who had home computer access and those students who did not have access was larger for NSLP-noneligible students than for NSLP-eligible students. This may be due to misclassification of some students with low-SES backgrounds as being not eligible for the NSLP or because the home computer access measure captures additional aspects of the income component of SES status that are not fully captured by NSLP eligibility.

Computer Use and Student Test Performance

Previous research (Laurillard, 2002; Thornburg, 1999; Papanastasiou, Zembylas, & Vrasidas, 2003) has suggested that how students use technology is more important than whether or not they use technology with respect to their academic achievement. The current study explored how computers and other technology devices were used in the three subject areas and how computer use was related to student performance. In each assessment, we identified a set of items that measures students' general computer practice and another set of items that measures students' more focused computer practice in the subject-area domain.

In the 2011 NAEP Writing Computer-Based Assessment, we identified a set of items that captured students' use of the computer for school writing activities, including writing a first draft, making changes, completing their writing, getting information from the Internet, and writing school assignments. Another set of items captured students' use of the computer for general purposes, including writing e-mails, writing using the Internet, and writing that is not part of schoolwork.

In the 2011 Mathematics Computer-Based Assessment, we identified a set of items that measured students' use of different types of mathematics-related computer programs at school and another set of items that measured students' general use of the computer for mathematics practice.

In the 2013 TEL pilot assessment, there is a set of items that measures students' specific computer practice in creating spreadsheets or presentations, both at school and outside of school. The assessment also contains items that capture students' more general use of the computer or other digital technology, both at school and outside of school, including sending or receiving messages; creating, editing, or organizing digital media; and sending, sharing, presenting, or uploading digital media.

2011 NAEP Writing Computer-Based Assessment

In the 2011 writing assessment, female, White, and NSLP-noneligible students reported engaging in school-related writing practices more often than male students, Black and Hispanic students, and NSLP-eligible students, respectively. However, Black and Hispanic students reported using the computer more often for general writing activities than did White students, as did city students in comparison to suburb, town, and rural students. Both general computer use and more focused computer use for writing are positively associated with overall student achievement in writing, but the benefit is more evident for focused school-related writing, even after students' sociodemographic memberships are controlled. In addition, the positive relationship between more focused computer use and writing achievement is more pronounced for NSLP-noneligible students, who reported engaging in focused school-related writing practices more often than students eligible for the NSLP.

2011 NAEP Mathematics Computer-Based Study

The 2011 mathematics assessment data, however, yields a different pattern of relationships between computer use and student achievement. In mathematics, general computer use is not related to overall student achievement on the computer-based assessment after controlling for sociodemographic membership. The use of different types of computer programs is negatively related to students' mathematics achievement, indicating that more frequent use of computer programs for mathematics is associated with poorer performance on the MCBS.

The newly published report from the Organization for Economic Cooperation and Development (OECD), *Students, Computers and Learning: Making the Connection* (OECD, 2015), also reveals a negative relationship between mathematics achievement and students' use of computers for mathematics in the 2012 PISA computer-based assessment in mathematics. A similar pattern was found in the following assessments: the 2006 PISA assessment in mathematics literacy (Ziya, Dogan, & Kelecioglu, 2010), the 2000 PISA assessment in science literacy (Papanastasiou, Zembylas, & Vrasidas, 2003), and the 1995 Trends in International Mathematics and Science Study (TIMSS) in science (Papanastasiou, 2002).

It is possible that students with low mathematics proficiency are more likely to engage in remedial interventions that employ mathematical computer programs instead of traditional instruction and drills. Unfortunately, NAEP does not currently contain measures designed to elicit information about prior student achievement or about the underlying reasons for using computer programs. Future studies may want to incorporate these measures to see if they can shed light on the negative relationship between computer program use and eighth-grade students' achievement in mathematics. In addition, research could be conducted to examine students in grades 4 and 12 to see if the negative relationships between computer program use and mathematical achievement on NAEP computer-based assessments also hold true for younger or older students.

The negative relationship between mathematical computer program use and students' mathematical achievement also raises a concern about the effectiveness of computer programs used to promote and facilitate students' mathematics learning. We know that computers have been widely used in this manner—and that students welcome and engage in this technology—but does this use and enthusiasm translate into effective learning in different subject-area domains? From 2004 to 2006, the National Center for Education Evaluation and Regional Assistance conducted a longitudinal experimental research study to examine the effectiveness of a range of reading and mathematics software products (Dynarski et al., 2007; Campuzano et al., 2009). The researchers recruited 132 low-income schools from 33 districts that have a higher-than-average percentage of NSLP-eligible students at the district and school levels. Their findings indicated that differences in student test scores were not statistically significant in classrooms that were randomly assigned to use the computer software products. After a year of continuous use of the software products, there was still no identifiable difference in test scores in reading. For sixth-grade mathematics, students' mathematics scores were statistically lower in the second year than in the first year. Since this research focused on low-income schools and districts, the skewed sample limits the generalizability of the findings. More evaluation research is needed to investigate the effectiveness of the computer programs currently implemented in schools.

2013 NAEP Technology and Engineering Literacy Pilot Assessment

In the TEL pilot assessment, we also identified two factors related to computer use. One factor reflects general computer and technology use (both at and outside of school) and another factor measures computer use for creating spreadsheets or presentations (both at and outside of school). For both factors, inverted U-shape curvilinear relationships with student achievement on TEL were identified. When students reported a medium frequency of computer use, their TEL scores were significantly higher than the scores of those who never or hardly ever used computers for TEL-related activities. In addition, students who reported using a computer on a daily basis for TEL-related activities had scores that were lower, on average, than the scores of those who reported a medium frequency of use. This suggests that students' technology and engineering literacy may not depend solely on the extent to which they are exposed to TEL-related activities. Their proficiency may come from other sources, such as reading (through the Internet or newspapers) and watching TV news. Daily use of a computer for certain activities may distract students and take too much of their time when they should be focusing on domain learning.

The curvilinear relationships also raise a concern about the validity of "every day" as a response option for the set of items that measure creating spreadsheets and presentations. When eighth-graders were questioned about the frequency of creating spreadsheets and presentations in the TEL pilot assessment, more NSLP-eligible students and Black students reported daily use of creating spreadsheets and presentations than their counterparts. Their "every day" responses may reflect a true phenomenon, but it may also indicate a validity problem associated with measurement bias, such as social desirability or a tendency to choose extreme options. In a validity study that evaluates NAEP student contextual questions related to computer use, Hedges, Konstantopoulos, and Thoreson (2000) noted that for some NAEP student contextual questions that query students on the frequency of events, the validity of "every day" as a response option is questionable. Further research should be conducted to see if narrowing the range or collapsing some categories may reveal different patterns.

Additional Analyses Using a NAEP Paper-and-Pencil Assessment

This study used NAEP computer-based assessment data to explore the relationships between students' familiarity with computers and their achievement in three subject areas. Since it was not clear whether the patterns revealed in this study occurred only in computer-administered assessments, we replicated our analyses using a comparable paper-and-pencil assessment—the 2011 NAEP operational paper-and-pencil assessment in mathematics—to see if the patterns would still hold.

The findings from our analyses of the 2011 NAEP operational mathematics assessment suggest that students' math-related computer use and mathematics performance exhibit similar relationships and magnitudes of effect in a paper-and-pencil assessment as those found in the MCBS (see Table 17). From this we can infer that, in grade 8, assessment mode is not likely to have a differential effect on the relationship between student performance and measures of computer access and familiarity. This is an encouraging result, suggesting that the transition from a paper-and-pencil assessment to a DBA may at least not exacerbate the disadvantage faced by students without home computer access. A more detailed description of the additional analyses and results is presented in Appendix C.

Table 17. Comparison of regression models for the 2011 NAEP Mathematics Computer-Based Study and the 2011 NAEP mathematics paper-and-pencil operational assessment

Variables	Final model MCBS		Final model Mathematics paper-and-pencil assessment	
	Estimate	Standard error	Estimate	Standard error
Intercept	314.9 *	1.34	316.7 *	0.43
Computer access				
No computer	-9.6 *	1.95	-11.1 *	0.65
Using computer programs	-9.9 *	0.64	-11.9	0.22
Using computer in general	[1]		[1]	
Gender				
Male	[1]		2.1 *	0.32
Race/ethnicity				
Black	-15.5 *	1.95	-17 *	0.5
Hispanic	-9.3 *	1.62	-12.3 *	0.5
Asian	16.6 *	2.77	14.8 *	0.98
Other	-6.6	3.72	-7.6 *	0.83
NSLP eligibility				
Eligible	-15.6 *	1.38	-15.5 *	0.39
R squared	0.247		0.269	

[1] Not included in the final model as the coefficient was insignificant in prior models.
Note: The having a computer at home, female, White, and not eligible for the NSLP subgroups are the reference groups. An asterisk indicates that the estimate is statistically significant at the .05 level.

Limitations

Recognizing that the data are cross-sectional and correlational by nature, we cannot reach causal conclusions or identify explicit causes. Future experimental studies could be conducted to examine the specific mechanisms that explain the relationships between computer access and use and student test performance. Another limitation of the current study is that it focused on student-level data in each assessment. As Hedges, Konstantopoulos, and Thoreson (2000) suggested, incorporating teacher-level information with respect to the use of computers and technology may provide a more complete picture about the relationship between computer familiarity and student achievement.

Recommendations

NCES may want to keep in mind some of the results from this study as it considers possible changes to future contextual questions. For example, some of the results from the TEL assessment suggested curvilinear relationships between the scores built from the items and NAEP TEL performance. As noted, some of these results seem to be counterintuitive, which raises questions about their validity. Of particular concern was the finding that students who reported the use of spreadsheets and presentations on a daily or near daily basis had the lowest performance on NAEP TEL. It strains credulity to believe that any student is using a computer to generate a spreadsheet or make a presentation on a daily basis. One way to deal with this issue would be to eliminate the "near daily" use category. Another approach would be to add a temporal reference, by adding language such as "In the past month," or "In the past week…" Focusing on a particular span of time may help students think more realistically about the number of times they have engaged in a particular use or activity. More generally, it would improve the questions if NCES ensured that the response categories are logical fits to the various computer uses that students are asked about.

A second approach to examining the validity of student responses would be to ask the same or similar questions of teachers as are asked of students, since in all NAEP assessments, except at grade 12, teacher questionnaires are linked to student questionnaires. Linking the two questionnaire sets would allow NCES to test broadly for consistencies or inconsistences in responses between students and teachers. For example, in addition to asking students how often they use spreadsheets or make presentations using the computer, teachers could be asked how often they assign students to do these tasks. The teachers' responses could then be compared with those of their students. While this comparison would not be exact—teachers respond about their average students, not just the students sampled for NAEP—one would still expect the information that teachers provide not to vary too much from the information that the sampled NAEP students provide, at least at the aggregate level.

The report contains other instances of seemingly counterintuitive findings. For example, in the MCBS, a negative relationship was found between using computers for mathematics and student performance on the mathematics assessment. This relationship was found to be more common among Black, Hispanic, and NSLP-eligible students than among White and NSLP-noneligible students.

When combined, these results led to the conjecture that teachers may have been using these tools with students who need remedial work in mathematics. Here too, having teacher data linked to student data could be helpful (teachers could be asked which of the various computer tools they use for remedial instruction and how often they use them). It might also be helpful to ask students themselves whether the teacher uses the computer to help them when they are having trouble learning. This question could be used to moderate the relationship between computer use for mathematics and NAEP mathematics performance. A parallel set of questions could be developed for reading and science (or any other NAEP subject area) as well.

Finally, as NAEP moves to a technology-based assessment, it would make sense for NCES to focus on the use of particular technologies, since it is important to know whether any student subgroup is disadvantaged by the technology being used. However, going forward, there is likely to be more value in knowing how technology is being used for instruction and learning than on what technology is being used. That is, it will be important for NCES to understand how technology is being used in the classroom and to examine the degree to which students taking NAEP assessments have been exposed to these uses.

NCES should also undertake special studies in schools that are leaders in the integration of technology with curriculum, instruction, and assessments in order to understand what to include in the student and teacher contextual questionnaires in the future. These studies would inform NCES about the various ways in which technology is being used. This is not to say that it is unimportant to have information about students' *access* to and *familiarity* with specific technologies, but that it is more important to understand *how* technology is being used in the classroom and the extent of students' exposure to this technology.

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Appendix A. 2013 NAEP Technology and Engineering Literacy Pilot Assessment Factor Analysis

Exploratory Factor Analysis

In the 2013 NAEP Technology and Engineering Literacy (TEL) pilot assessment student contextual questionnaire, we initially identified 32 variables related to computer and/or technology use and familiarity. After the initial screening, one variable was excluded as it was only nominally related to the area of interest. Therefore, the initial analyses were conducted with 31 items, which are either binary or ordered categorical variables. Exploratory factor analysis (EFA) was conducted using Mplus 7.0 (Muthén & Muthén, 1998–2012), while treating indicator variables as categorical. The Mplus default estimator for categorical indicators, weighted least squares with mean and variance (WLSMV) adjusted estimation, was used for the EFA analysis with the student weight variable applied.[1] Oblique Geomax rotation, allowing factors to be correlated, was used for the final EFA results.[2]

In the 2013 TEL pilot assessment, a portion of the contextual questionnaire items, including the computer-related items identified for this study, were spiraled over 10 booklets and groups of test takers. Students administered the same booklet are referred to as a "pattern group." Ten pattern groups were identified based on the 31 computer-related items. The number of items administered to each of the 10 groups varied, ranging from 7 to 23 out of the 31 total computer-related items. Each pattern group consists of approximately 10 percent of the entire sample.

Because of the "missing by design" nature of the 2013 TEL pilot assessment data, we ran an EFA for the overall sample as well as for each of the 10 pattern groups.

For the overall sample and for each pattern group, two-, three- and four-factor structures were compared using model fit indices (i.e., RMSEA, CFI, TLI, and SRMR), scree plots, factor loadings, and factor correlations. Overall, a three-factor solution appeared to best represent the data, based on model fit indices and factor loadings for 14 variables.[3] The three factors represent (1) *general computer use*, (2) *computer use for spreadsheets or presentations*, and (3) *computer self-efficacy.*

Table A-1 presents selected results from the exploratory factor analysis of the computer use variables in the TEL pilot assessment.

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[1] The EFA was run with and without the student weight variable using WLSMV. It was also run with maximum likelihood estimation (which does not allow for a student weight variable) to compare the parameter estimations. All of the results were reasonably consistent.

[2] Two rotation techniques, oblique Geomax and Promax, were utilized in the EFA; outcomes from the two techniques were comparable and reasonably consistent. Thus, the oblique Geomax rotation solution was used when making decisions for further analyses, as recommended by the Mplus developers.

[3] After carefully reviewing the EFA outcomes, the variable correlations, and the Educational Testing Service (ETS) TEL pilot study report (ETS 2013), we decided to exclude 17 variables that were not included in the 2014 TEL administration; thus, 14 variables were retained for further analysis.

Table A-1. Structure of the exploratory factor analysis of computer use-related variables in the 2013 NAEP Technology and Engineering Literacy pilot assessment

Variables	Factor 1 (general computer use)	Factor 2 (computer use for spreadsheets/ presentations)	Factor 3 (self-efficacy)
Send or receive messages via pc	**0.730**	-0.010	-0.381
Create, edit, or organize digital media via pc	**0.654**	0.204	-0.005
Send/share/present/upload digital media via pc	**0.862**	0.125	-0.243
Send or receive messages out of school	**0.658**	-0.274	0.149
Create/edit/organize digital media out of school	**0.573**	0.114	0.335
Send/share/present/upload digital media out of school	**0.654**	-0.009	0.300
Create a spreadsheet via pc	-0.026	**0.628**	0.178
Create a presentation via pc	0.091	**0.534**	0.230
Create a spreadsheet out of school	0.006	**0.894**	-0.029
Create a presentation out of school	0.110	**0.760**	0.020
Able to publish or maintain a personal website or blog	0.167	-0.040	**0.610**
Able to create presentations with sounds, pictures, or video	0.098	-0.021	**0.776**
Able to organize information into a chart, graph, or spreadsheet	-0.126	0.088	**0.821**
Able to compare products using the Internet	0.021	0.034	**0.713**

Note: Factor loadings of .40 and above are marked in **bold**. The EFA results are based on a sample size of 11,170.

To better understand the dimensionality of the items and obtain factor scores, a confirmatory factor analysis was next conducted using the 14 items.

Confirmatory Factor Analysis

A confirmatory factor analysis (CFA) was conducted using Mplus for the 14 computer-related variables identified through the exploratory factor analysis and the 11,170 students who were administered at least one of the 14 computer-related items and did not have omitted responses. The WLSMV estimator with student weights applied was chosen for the CFA.

Based on item loadings and model fit indices from the EFA, two- and three-factor CFA models were fitted to the data. We also fitted the CFA models to the subsample of 1,620 students who were administered all 14 items.[4] The results were compared using model fit indices, factor loadings, and factor correlations within each sample.

The three-factor model seemed to be better than the two-factor model because it showed a better model fit. As in the EFA, factor 1 appears to indicate students' general experience with information and communication technology (ICT) activities (at school and outside of school); factor 2 appears to capture students' experience with creating spreadsheets and presentations; and factor 3 seems to reflect students' self-efficacy in performing TEL-related tasks. The

[4] This sample includes students with omitted responses. As all items were given to this group of students, it was not necessary to delete students with omitted responses.

structure of the three-factor CFA model and factor correlations are presented in Table 12 in the "Results" section of this report.

Appendix B. Items for computer access at home and for the variables underlying the computer use factors in the WCBA, MCBS, and TEL pilot assessment at grade 8

Items for computer access at home and for the variables in the two factors in the analysis of the 2011 NAEP Writing Computer-Based Assessment (WCBA)

Computer access at home: One variable

VE011103

5. Is there a computer at home that you use?

Ⓐ Yes

Ⓑ No

Factor 1 – Using computer for school writing activities: Five variables

VE036314

9. For school this year, how often do you use each of the following when you write a paper or report? Select **one** circle on each line.

	Never or hardly ever	Sometimes	Very often	Always or almost always	
a. Use the Internet to look for information to include in the paper or report	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VE036318
b. Use a computer from the beginning to write the paper or report (for example, use a computer to write the first draft)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VE036315
c. Use a computer to make changes to the paper or report (for example, spell-check or cut and paste)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VE036316
d. Use a computer to complete your writing	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VE088274

10. How often do you use a computer, in and out of school, for each of the following activities? Select **one** circle on each line.

	Never or hardly ever	Once or twice a month	Once or twice a week	Every day or almost every day	
a. Writing for school assignments (for example, reports, essays, or letters)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VE107503

Factor 2 – Using computer for general writing: Three variables

10. How often do you use a computer, in and out of school, for each of the following activities? Select **one** circle on each line.

	Never or hardly ever	Once or twice a month	Once or twice a week	Every day or almost every day	
b. Writing that is not part of your schoolwork	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VE107504
c. Writing e-mails	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VE107505
d. Writing using the Internet (for example, for blogs or personal web pages)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VE107507

Items for computer access at home and for the variables in the two factors in the analysis of the 2011 NAEP Mathematics Computer-Based Study (MCBS)

Computer access at home: One variable

VE011103

5. Is there a computer at home that you use?

Ⓐ Yes

Ⓑ No

Factor 1 – Using computer programs for math: Eight variables

13. When you are doing math for school or homework, how often do you use these **different types of computer programs**? Select **one** circle on each line.

	Never or hardly ever	Once every few weeks	About once a week	Two or three times a week	Every day or almost every day	
a. A spreadsheet program for math class assignments	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE401623
b. A program to practice or drill on math facts (addition, subtraction, multiplication, division)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE401624
c. A program that presents new math lessons with problems to solve	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE401625
e. A calculator program on the computer to solve or check problems for math class	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE401627
f. A graphing program on the computer to make charts or graphs for math class	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE401628
g. A statistical program to calculate patterns such as correlations or cross tabulations	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE401629
h. A word processing program to write papers for math class	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE401630
i. A program to work with geometric shapes for math class	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE401631

Factor 2 – Using computer for math in general: Three variables

VE401590

10. How often do you use a computer for math at school?

Ⓐ Never or hardly ever

Ⓑ Once every few weeks

Ⓒ About once a week

Ⓓ Two or three times a week

Ⓔ Every day or almost every day

VE401594

11. Do you use a computer for math homework at home?

Ⓐ Yes

Ⓑ No

VE401615

12. On a typical day, how much time do you spend doing work for math class on a computer? Include work you do in class and for homework.

Ⓐ None

Ⓑ Half an hour or less

Ⓒ About 1 hour

Ⓓ About 2 hours

Ⓔ More than 2 hours

Items for computer access at home and for the variables in the three factors in the analysis of the 2013 NAEP Technology and Engineering Literacy (TEL) pilot assessment

Computer access at home: One variable

VE011103

4. Is there a computer at home that you use?

Ⓐ Yes

Ⓑ No

Factor 1 – Computer use for spreadsheets or presentations: Four variables

21. **For school work**, how often do you use a computer or other digital technology for the following activities? Select **one** circle in each row.

	Never or almost never	A few times a year	Once or twice a month	Once or twice a week	Every day or almost every day	
e. Create a presentation	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE639137
f. Create a spreadsheet (a table or grid that displays data into columns and rows and may be used to create charts and graphs)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE639136

23. In this question, please think about activities you do that are not related to your school work. How often do you use a computer or other digital technology for the following activities **not for school work**? Select **one** circle in each row.

	Never or almost never	A few times a year	Once or twice a month	Once or twice a week	Every day or almost every day	
e. Create a presentation	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VF025117
f. Create a spreadsheet (a table or grid that displays data into columns and rows and may be used to create charts and graphs)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VF025116

Factor 2 – General computer use: Six variables

21. **For school work**, how often do you use a computer or other digital technology for the following activities? Select **one** circle in each row.

	Never or almost never	A few times a year	Once or twice a month	Once or twice a week	Every day or almost every day	
a. Send or receive messages (for example, chat, e-mail, instant messages, text messages)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE639125
c. Create, edit, or organize digital media	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE639130
d. Send, share, present, or upload digital media	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE639131

23. In this question, please think about activities you do that are not related to your school work. How often do you use a computer or other digital technology for the following activities **not for school work**? Select **one** circle in each row.

	Never or almost never	A few times a year	Once or twice a month	Once or twice a week	Every day or almost every day	
a. Send or receive messages (for example, chat, e-mail, instant messages, text messages)	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VF025109
c. Create, edit, or organize digital media	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VF025112
d. Send, share, present, or upload digital media	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VF025113

Factor 3 – Computer self-efficacy: Four variables

25. Do you think that you would be able to do each of the following? Select **one** circle in each row.

	I definitely can't	I probably can't	Maybe	I probably can	I definitely can	
a. Publish or maintain a personal website or blog	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE682218
b. Create presentations with sound, pictures, or video	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE682219
c. Organize information into a chart, graph, or spreadsheet	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE682221
d. Compare products using the Internet	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VE682222

Appendix C. Computer Familiarity and NAEP Mathematics Performance in the Paper-and-Pencil Mode

Since the study described in the body of this report focused only on digital-based assessments (DBAs), it was not clear whether or not the relationships that were found between computer familiarity and academic performance were due primarily to the assessment mode. Therefore, we decided to replicate these analyses using a paper-and-pencil assessment.

Among the three DBAs—the 2011 Writing Computer-Based Assessment (WCBA), the 2011 Mathematics Computer-Based Assessment (MCBS), and the 2013 Technology, Engineering, and Literacy (TEL) pilot assessment—only the MCBS had a comparable operational paper-and-pencil assessment administered in the same year to a nationally representative sample of eighth-grade students. Therefore, we could only replicate the analyses of computer familiarity and student performance in the area of mathematics using the 2011 NAEP MCBS and the 2011 NAEP mathematics paper-and-pencil operational assessment.

The aim of this additional study was to shed light on the question of whether computer access and use variables have similar relationships with student performance on a paper-and-pencil test as they do on a digital-based assessment. If our results confirmed that this was the case, it might decrease the probability that the assessment mode could be a factor that leads to potential performance differences when switching from a paper-and-pencil assessment to a DBA.

In addition, we aimed to examine whether the relationships found across different socio-demographic subgroups in the analyses of the digital-based assessments would still hold in the paper-and-pencil assessment.

Method

Data Sources

The data source for this study is the 2011 NAEP grade 8 mathematics operational assessment, a paper-and-pencil assessment. To ensure that the results from this study would be comparable to those obtained from the digital-based assessment, the analyses were performed using the same procedures. That is, they were restricted to the full sample of grade 8 public schools students (164,400 students). Listwise deletion (complete case analysis) was performed for students with missing data. The complete case sample (CC sample) includes 150,910 public school students. The characteristics of the sample (before and after listwise deletion) by major reporting groups are presented in Table C-1.

Table C-1. Sample composition of the 2011 NAEP mathematics paper-and-pencil operational assessment at grade 8, by selected characteristics

Characteristics	Full reporting sample[1]			Complete case sample[1]		
	Weighted total	Weighted percent	Standard error	Weighted total	Weighted percent	Standard error
Total	3,415,444	100		3,183,479	100	
Gender						
Male	1,730,815	50.7	0.09	1,595,660	50.1	0.11
Female	1,684,629	49.3	0.09	1,587,819	49.9	0.11
Race/ethnicity[2]						
White	1,832,545	53.7	0.27	1,742,292	54.7	0.28
Black	533,853	15.6	0.25	479,546	15.1	0.24
Hispanic	768,576	22.5	0.31	701,098	22.0	0.30
Asian	175,018	5.1	0.17	164,541	5.2	0.18
NSLP eligibility						
Eligible	1,628,589	47.7	0.33	1,497,918	47.1	0.33
Not eligible	1,772,180	51.9	0.33	1,685,561	52.9	0.33
Information not available	14,675	0.4	0.05			

[1] The full reporting sample includes only students with assessment data, and the complete case sample consists of the students after listwise deletion.
[2] Race/ethnicity categories do not add up to 100 percent since American Indian/Native American students, Pacific Islander students, and students of two or more race are not reported here. The three racial groups are not used as subgroups in the study due to their small sample sizes.
Note: Detail may not sum to totals due to rounding. To test the difference between the full reporting sample and the complete case sample, *t* tests were conducted. The differences in both genders, White, and not eligible for the NSLP are statistically significant at the .05 level of significance, but note that the differences are quite small.
Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2011 Mathematics Assessment.

Variables

The computer-related and student sociodemographic variables were drawn from the student contextual questionnaire of the 2011 NAEP mathematics paper-and-pencil operational assessment. Twelve variables were identified as being identical to the 12 computer-related variables used in the analysis of the MCBS. The outcome variables were the five plausible values of the scale scores, which are on a scale of 0 to 500.

Analysis Procedures

The analysis of the paper-and-pencil assessment used the same analytic procedures as were employed in the analysis of the MCBS. Please refer to the discussion of the MCBS in the "Results" section of the body of the report for details about the EFA and multiple regression procedures used to analyze the assessment data.

Summary of Results

Factor Structure of the Computer-Related Variables

Through exploratory factor analysis, we extracted two intercorrelated factors and one computer access variable that are equivalent to those identified in the MCBS.

The computer access variable is "Is there a computer at home that you use?"

Factor 1 consists of eight items that measure the frequency of using different types of computer programs when doing mathematics for school:

- a statistical program to calculate patterns (such as correlations or cross-tabulations),
- a program to work with geometric shapes in mathematics classes,
- a graphing program to make charts or graphs in mathematics classes,
- a word processing program to write papers in mathematics classes,
- a program to practice or drill on mathematical facts,
- a spreadsheet program for mathematics class assignments,
- a program that presents new mathematics lessons with problems to solve, and
- a calculator program to solve or check problems in mathematics classes.

Factor 2 contains three items that measure whether:

- students use a computer for math homework at home,
- the amount of time students spend doing work for mathematics class on a computer on a typical day, and
- the frequency with which students use a computer for math at school.

To maintain consistency with the analysis of the MCBS, factor 1 was labeled as *using computer programs for math* and factor 2 as *using computers for math in general*. The estimated reliability of the index built for factor 1 is .92; for factor 2, it is .71. Table C-2 presents a brief description of each variable and the loading of each variable on the two factors.

Table C-2. Structure of the factor analysis of computer use-related variables in the 2011 NAEP mathematics paper-and-pencil operational assessment at grade 8

Variable	Factor 1 (using computer programs for math)	Factor 2 (using computers for math in general)
Use statistical program for math class	**0.89**	-0.04
Use program to work with geometric shapes for math class	**0.84**	-0.01
Use word processing program for math class	**0.77**	0.01
Use graphing program for charts for math class	**0.77**	0.06
Use program to drill on math facts	**0.74**	0.05
Use spreadsheet program for math assignments	**0.74**	-0.02
Use program for new lessons on problem solving	**0.74**	0.07
Use calculator program for math class	**0.48**	0.29
Do you use a computer for math homework at home	-0.10	**0.87**
Time per day on computer for math work	0.11	**0.61**
Use computer at school for math	0.22	**0.43**

Note: Factor loadings of .40 and above are marked in **bold**.

Computer Familiarity Differences Across Sociodemographic Groups

To examine whether either of the two computer use factors and the computer access variable differ across selected sociodemographic groups (gender, race/ethnicity, NSLP eligibility, and urbanicity), *t* tests were used.

Computer access at home

The results for computer access in the NAEP mathematics paper-and pencil assessment are displayed in table C-3. Compared with the results from the MCBS, the paper-and-pencil assessment data yielded similar patterns in terms of computer access. That is:

- In total, 92.9 percent of students reported having computer access at home (92.6 percent in the MCBS).
- Black and Hispanic students reported lower percentages of home computer access (90.4 and 88.0 percent, respectively) than White and Asian students (95.3 and 97.9 percent, respectively) in the paper-and-pencil assessment. However, the Black and Hispanic percentages were slightly higher in the paper-and-pencil assessment than in the MCBS (88.2 and 87.3 percent, respectively).
- Students who were not eligible for the NSLP reported a higher percentage of home computer access than NSLP-eligible students (97.5 vs. 87.8 percent) in the paper-and-pencil assessment. However, the NSLP-eligible percentage was slightly higher in the paper-and-pencil assessment than in the MCBS (86.7 percent).
- Students in suburbs and rural areas reported higher percentages of home computer access than students in cities in the paper-and-pencil assessment, whereas only suburban students reported a higher percentage of computer access than city students in the MCBS.

Table C-3. Computer access at home in the 2011 NAEP mathematics paper-and-pencil operational assessment at grade 8, by selected characteristics

Characteristics	Weighted total	With computer at home		Difference between subgroups (percent)
		Percent	Standard error	
Total	3,183,479	92.9	0.12	
Gender				
Male	1,595,660	92.8	0.19	-0.3
Female	1,587,819	93.1	0.16	
Race				
White	1,742,292	95.3	0.12	
Black	479,546	90.4	0.28	-4.9 *
Hispanic	701,098	88.0	0.44	-7.3 *
Asian	164,541	97.9	0.26	2.6 *
NSLP eligibility				
Eligible	1,497,918	87.8	0.24	-9.6 *
Not eligible	1,685,561	97.5	0.10	
Urbanicity				
City	887,987	91.3	0.30	
Suburb	1,149,818	94.9	0.15	3.6 *
Town	411,194	91.8	0.27	0.5
Rural	734,480	92.5	0.25	1.1 *

Note: The difference between subgroups shows the difference in computer access at home between a subgroup and the reference group within a major reporting group. The female, White, not eligible for the NSLP, and city subgroups are the reference groups for the major reporting groups. An asterisk indicates that the difference is statistically significant at the .05 level.

Computer use factors

Table C-4 presents the results from the paper-and-pencil assessment for the two computer use factors. In terms of factor 1, *using computer programs for math* (at school), the results show that:

- Black, Hispanic, and Asian students reported a higher frequency of use than White students.
- Male students and NSLP-eligible students reported a higher frequency of use than female students and NSLP-noneligible students, respectively.
- City students reported a higher frequency of use than their counterparts in suburbs, towns, and rural areas.

These patterns are comparable to those found in the MCBS, with one exception: there was no significant difference in the use of computer programs between students in cities and towns in the MCBS.

In terms of factor 2, *using computers for math in general*, the results show that:

- Black, Hispanic, and Asian students reported a higher frequency of use than White students.

- NSLP-eligible students reported a higher frequency of use than NSLP-noneligible students.
- Students in cities reported a higher frequency of use than their counterparts in suburbs, towns, and rural areas.

These patterns of computer use are also similar to those found in the MCBS, with the exception of the difference between students in cities and towns; in the MCBS, this difference is not significant.

Table C-4. Computer familiarity indices for the 2011 NAEP mathematics paper-and-pencil operational assessment at grade 8, by selected characteristics

Characteristics	Factor 1 (using computer programs for math)			Factor 2 (using computer for math in general)		
	Mean	Standard error	Difference between subgroups	Mean	Standard error	Difference between subgroups
Total	1.8			1.6		
Gender						
Male	1.8	0.01	0.1 *	1.6	0.00	0.0
Female	1.7	0.01		1.6	0.00	
Race						
White	1.6	0.00		1.6	0.00	
Black	2.1	0.01	0.5 *	1.8	0.01	0.2 *
Hispanic	1.8	0.01	0.2 *	1.6	0.01	0.1 *
Asian	1.7	0.02	0.0 *	1.7	0.01	0.1 *
NSLP eligibility						
Eligible	1.9	0.01	0.3 *	1.7	0.00	0.1 *
Not eligible	1.6	0.00		1.6	0.00	
Urbanicity						
City	1.8	0.01		1.7	0.01	
Suburb	1.7	0.01	-0.1 *	1.6	0.01	0.0 *
Town	1.7	0.01	-0.1 *	1.6	0.01	-0.1 *
Rural	1.7	0.01	-0.1 *	1.6	0.01	-0.1 *

Note: The difference between subgroups show the difference in computer familiarity indices between a subgroup and the reference group within a major reporting group. The female, White, not eligible for the NSLP, and city subgroups are the reference groups for the major reporting groups, respectively. An asterisk indicates that the difference is statistically significant at the .05 level.

Computer Access, Computer Use, and Student Achievement in the 2011 NAEP Mathematics Paper-and-Pencil Operational Assessment

Multiple regression analyses were conducted to investigate relationships between students' achievement and their reported computer access and computer use in the 2011 NAEP mathematics paper-and-pencil operational assessment. The findings (shown in Table C-5) are as follows:

- On average, students with computer access at home scored 11.1 points higher on the paper-and-pencil assessment than those without access, controlling for gender, race/ethnicity, and NSLP eligibility (the difference was 9.6 points in the MCBS).
- There is a negative relationship in the paper-and-pencil assessment between *using computer programs for math* and students' math achievement, both before and after controlling for students' sociodemographic variables. A negative relationship was also found in the MCBS, but the magnitude of the relationship is slightly larger in the paper-and-pencil assessment.
- As in the MCBS, there was no significant relationship in the paper-and-pencil assessment between students' math achievement and *using computers for math in general.*

Table C-5. Regression models for the analysis of the 2011 NAEP mathematics paper-and-pencil operational assessment sample at grade 8

Variables	Base model: Estimate	Base model: Standard error	Control model: Estimate	Control model: Standard error
Intercept	311.8 *	0.59	316.7 *	0.43
Computer access				
No computer	-20.0 *	0.67	-11.1 *	0.65
Using computer programs	-15.2 *	0.25	-11.9 *	0.22
Using computer in general	0.2	0.41		
NSLP eligibility				
Eligible			-15.5 *	0.39
Gender				
Male			2.1 *	0.32
Race/ethnicity				
Black			-17.0 *	0.50
Hispanic			-12.3 *	0.50
Asian			14.8 *	0.98
Other			-7.6 *	0.83
R squared	0.141		0.269	

Note: The having a computer at home, female, White, not eligible for the NSLP, and city subgroups are the reference groups. An asterisk indicates that the estimate is statistically significant at the .05 level.

Finally, we tested the interactions between computer familiarity variables and student sociodemographic variables through multiple regression analyses. Three interactions were significant after controlling for main effects and sociodemographic variables (whereas in the

MCBS, no significant interaction was discovered). These interactions are (1) NSLP and computer access, (2) race/ethnicity and factor 1, *using computer programs for math*, and (3) NSLP and factor 1, *using computer programs for math*.

Even though these interactions are statistically significant, their magnitude is small and adding them into model 2 (with main effects and sociodemographic variables) only increases *R* squared by about .001, which does not add much to the explained variance in students' achievement scores in the NAEP mathematics paper-and-pencil assessment. Thus, these interactions have not been included in the final model.

In summary, the findings from the study of the paper-and-pencil assessment suggest that students' math-related computer use is related to their mathematics performance, and the results exhibit similar relationships and magnitudes of effects as those found in the MCBS. This confirms our hypothesis that the assessment mode change from paper-and-pencil to digital is not likely to impact students' performance on the NAEP mathematic assessment. This is an encouraging result, and it may suggest that the transition may not exacerbate the disadvantage faced by students without computer access at home and/or by those who have less familiarity with computers. However, further research should be conducted to investigate the negative relationship between the use of math computer programs and students' math achievement.

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