Developing New Indices to Measure Digital Technology Access and Familiarity

Sami Kitmitto, American Institutes for Research

George W. Bohrnstedt, American Institutes for Research

B. Jasmine Park, American Institutes for Research

Jonas Bertling, Educational Testing Service

Debby Almonte, Educational Testing Service

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Panel Members:

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University of Connecticut

George W. Bohrnstedt
American Institutes for Research

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Research Triangle Institute

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Council of Chief State School Officers

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David Thissen
University of North Carolina at Chapel Hill

Gerald Tindal
University of Oregon

Sheila Valencia
University of Washington, Seattle

Project Director:
Frances B. Stancavage
American Institutes for Research

Project Officer:
Grady Wilburn
National Center for Education Statistics

For Information:
NAEP Validity Studies (NVS)
American Institutes for Research
2800 Campus Drive, Suite 200
San Mateo, CA 94403
Phone: 650/376-6363

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Executive Summary

The National Assessment of Educational Progress (NAEP) is in the process of transitioning from being a paper-based assessment (PBA) to a digitally based assessment (DBA). An important issue is the degree to which all children are ready for the move and whether any of NAEP's reporting subpopulations are being disadvantaged by the transition. If technology access and familiarity are correlated with NAEP DBA performance and if there is differential access to digital technology, this could lead to results that differ from PBA, which has been used to assess trends since 1990 for mathematics and 1992 for reading.

To investigate these issues, we developed a new set of survey items measuring access to, familiarity with, and self-efficacy for digital technology. A common set of items measuring access to and familiarity with digital technology and a measure of self-efficacy in dealing with digital technology were developed for Grades 4, 8 and 12. Additional items dealing with more advanced uses of digital technology as well as a measure of familiarity with digital concepts were developed for the Grade 8 and 12 samples. The item set measuring familiarity with digital concepts also included items with some fictitious digital concepts that allowed the study to assess the degree to which students were overclaiming knowledge of digital concepts.

The items were administered as a special study as part of the 2015 NAEP using samples of schools from the operational PBA administration and the DBA start-up administration. The study examined five major research questions:

1. Do the access, familiarity, and self-efficacy items cluster together in ways that suggest that reliable indices of each can be constructed?
2. Are access, familiarity, and self-efficacy differentially distributed across gender, race/ethnicity, and/or socioeconomic status (SES)?
3. What is the relationship between access, familiarity, and self-efficacy and performance on NAEP?
4. Is there differential validity of the indices in predicting NAEP performance across modes of administration?
5. Do the observed relationships between indices and NAEP performance change when controlling for SES and other student characteristics?

The first research question was examined using exploratory and confirmatory factor analyses. The results from these analyses indicated that both the access and familiarity domains are multidimensional. For the access domain, two factors were identified that were interpreted as "access at home" and "access at school." For the familiarity domain, three factors were identified, "familiarity through instruction," "familiarity through computer use," and "familiarity through tablet use," and two additional factors at Grades 8 and 12, "familiarity with digital concepts" and "overclaiming of familiarity with digital concepts." The factor analyses indicated that a single factor described the "self-efficacy with digital technology" items. Indices were built for each of the factors observed and the reliabilities for each computed. The reliability estimates for the indices were in the acceptable range for all the factors

at all grades except for those associated with the "access at home" and "access at school" factors, both of which were based on only a few items.

Means were computed for the indices by grade level to examine whether access, familiarity, and self-efficacy differentially distributed across gender, race/ethnicity, and SES. We did not find substantial differences (statistically significant and greater than 0.2 standard deviations) between male and female students. Nor did we find evidence that Black and Hispanic students were disadvantaged because of a lack of access to digital technology either at home or at school. Although not anticipated, disadvantaged students were much more likely to indicate familiarity with digital technology through the use of tablets, and to a lesser extent through the use of computers, than their more advantaged counterparts. However, we did find that disadvantaged subpopulations generally reported lower digital self-efficacy and less familiarity with digital concepts than nondisadvantaged students.

Regression analyses were used to examine the third and main research question—the relationship between access, familiarity, and self-efficacy and performance on NAEP. The expectation was that relationships between the indices of access and familiarity with digital technology and NAEP scores would be positive. Although some indices were positively related (especially strongly related were familiarity with digital concepts and self-efficacy), others were negatively related (access at school, familiarity through computer use, familiarity through tablet use) and the relationship of access to NAEP scores was in all cases but one not statistically significant.

Regression analyses also were used to examine the fourth research question—whether there was differential validity for the indices in predicting NAEP performance across modes of administration. We did not observe that associations between the digital technology access, familiarity, and self-efficacy indices and NAEP scores varied much across the DBA and PBA samples. In most cases, differences were not statistically significant and, when differences were observed, they often were in the opposite direction from that which was hypothesized.

Finally, in examining research question 5, we did not observe any significant differences between the DBA and PBA samples in the estimated associations between the indices and NAEP achievement when controlling for potentially important sociodemographic characteristics of students.

In summary, the hypothesis that student access and familiarity with digital technology would be related to student performance was not substantiated in this study. Indeed, some of the relationships went in the opposite direction from that hypothesized; this was especially true for the use of tablets in school. One possibility is that digital technology (especially tablets) is being used as an alternative opportunity to learn for low-performing students in some schools and, if so, giving a child work on a tablet could be associated with low prior achievement. If it is the case that laptops, and especially tablets, are being used for teaching low-performing students, prior achievement would be an omitted variable in our analysis. Not only would prior achievement be linked positively to classroom tablet (or laptop) use, but also negatively to NAEP performance. This, in turn, could lead to a negative observed relationship between an index such as tablet familiarity and NAEP performance. The study has been repeated as part of the 2017 NAEP assessment, which will allow an examination of the replicability of the 2015 results.

Introduction

The National Assessment of Educational Progress (NAEP) is in the process of transitioning from being a paper-based assessment (PBA) to a digitally based assessment (DBA). An important issue is the degree to which all children are ready for the move and whether any of NAEP's reporting subpopulations are being disadvantaged by the transition. If technology access and familiarity are correlated with NAEP DBA performance and if there is differential access to digital technology, this could lead to results that differ from PBA, which has been used to assess trends since 1990 for mathematics and 1992 for reading.

To investigate these issues, we developed a new set of survey items measuring access to, familiarity with, and self-efficacy for digital technology. Although the primary focus of the study is on access to and familiarity with digital technology, we also added items to measure self-efficacy for digital technology to the survey because a recent American Institutes for Research (AIR) study (Broer, Park, Bohrnstedt, & Kim, 2015) showed that digital self-efficacy was significantly related to performance on the 2013 NAEP Technology and Engineering Literacy (TEL) pilot assessment net of other contextual factors.

The items were administered as a special study as part of the 2015 operational NAEP administration using samples of schools in which some schools were administered the PBA version of NAEP and others the DBA version. Using the responses to the new survey items, we first explored whether students have differential access to, familiarity with, and experience with the digital devices, particularly whether there is differential access for disadvantaged students (e.g., those with low socioeconomic status [SES], minority students). Second, we used responses to the new survey, as well as NAEP cognitive items, to understand the relationship between digital technology access, familiarity, and self-efficacy with performance on NAEP in both the PBA and DBA modes of administration.

Specifically, the study examined five major research questions:

1. Do the access, familiarity, and self-efficacy items cluster together in ways that suggest that reliable indices of each can be constructed?
2. Are access, familiarity, and self-efficacy differentially distributed across gender, race/ethnicity, and/or SES?
3. What is the relationship between access, familiarity, and self-efficacy and performance on NAEP?
4. Is there differential validity of the indices in predicting NAEP performance across modes of administration?
5. Do the observed relationships between indices and NAEP performance change when controlling for SES and other student characteristics?

Background

NAEP has been a paper-and-pencil assessment since its inception, but that has begun to change. Prior to the 2015 study reported here, there were three NAEP assessments administered by computer, beginning in 2011 with the Grades 8 and 12 writing assessments. There also was a small Mathematics Computer-Based Study (MCBS) in 2011, and the Technology and Engineering Literacy (TEL) assessment was administered by computer in 2104. For the 2015 study reported here, the NAEP results from the operational assessments in mathematics, reading, and science were based on PBA versions, but equivalent samples of students took the assessments on tablets, and analyses were carried by the NAEP contractor, Educational Testing Service (ETS), to examine for mode effects on performance. The operational 2017 NAEP assessments in mathematics, reading, and writing were all given on tablets; in addition, a sample of students in each state took the assessment using paper and pencil to assess possible mode effects in the states. A sample of schools was drawn in which all students were again given the items developed for the study reported here and where some of the students took the PBA version of the operational test and others the DBA version. These data will allow the National Validity Studies Panel (NVS Panel), in a separate report, to determine if the results found here are replicated with the 2017 study data.

Given the growth in technology in society as well as in the classroom, taking assessments online is not new. The Graduate Record Examination (GRE) and the Armed Forces Vocational Aptitude Battery (ASVAB) have had online versions of their tests for several years. A few states had been administering their achievement tests using a digital platform prior to 2015, but online state testing accelerated greatly with the move to Common Core State Standards (CCSS) testing. Both of the CCSS testing consortia, the Smarter Balanced Assessment Consortium (Smarter Balanced) and the Partnership for Assessment of Readiness for College and Careers (PARCC), delivered the vast majority of their assessments on desktops or laptops in 2015 and 2016, although there also was a paper-and-pencil version available for those schools that did not yet have the infrastructure to support computer-based assessments. Thus, the NAEP transition to a DBA is very much in step with the way that large-scale testing of elementary and secondary students is moving in this country.

Although there are important concerns about mode effects and maintaining trend in NAEP scores, the National Center for Education Statistics (NCES) is addressing these issues in other lines of research. An additional validity issue, addressed by this study, is the extent to which the change in mode might impact students with less exposure to digital technology, particularly NAEP's reporting subgroups. In the remainder of this section, we summarize what we know from the literature about student access to and familiarity with digital technology in the United States, and how these factors might relate to performance assessments.

Student Access to Technology

In the standard contextual questionnaires administered with NAEP, students were asked about home access to a computer and an Internet connection (two separate questions). Looking at variation by race/ethnicity in the 2015 mathematics and reading assessments at Grade 8, 92 percent of White students reported having access to a computer at home compared with 83 percent and 82 percent for Black and Hispanic students, respectively. When examining Internet access at home, the pattern of results is the same, although the difference is smaller—96 percent of White students in Grade 8 reported having access compared with 95 percent of Black students and 93 percent of Hispanic students.

At Grade 4, 88 percent of White students indicated that they had a computer at home compared with 76 percent of Black students and 77 percent of Hispanic students. For Internet access, the comparable figures are 89 percent for Whites, 75 percent for Blacks, and 74 percent for Hispanics. Comparing these numbers with the Grade 8 results suggests there is a larger "digital divide" at Grade 4 than at Grade 8.

As NAEP does not ask students about income, it was not possible to examine its relationship to computer access at home. However, the Teenage Research Unlimited (TRU) study (described in more detail below) found that use of technology in the home varied as a function of household income. For example, 21 percent of those from households with incomes less than $25,000 per year reported using a tablet at home compared with 49 percent who reported household incomes of $50,000 per year or greater. Access to the Internet at home was broken out by whether students were in Title I or non-Title I schools. For students in Grades 3–5, 94 percent at non-Title I schools reported having Internet access at home compared with 87 percent for those in Title I schools. In Grades 6–8, the comparable figures were 96 percent and 90 percent, respectively, while in Grades 9–12, they were 95 percent and 91 percent, respectively. That is, although there were differences in Internet access by Title I school status, the vast majority of all students reported having Internet access. The report did not break out results by race/ethnicity.

The 2015 Project Tomorrow study, based on more than 430,000 K–12 student responses collected in 2014 in over 8,000 schools (Project Tomorrow, 2015) indicates that 23 percent of those in Grades 6–8 and 58 percent of those in Grades 9–12 reported using their own devices in school. Thirty-four percent of those in Grades 6–8 and 32 percent of those in Grades 9–12 said they use school-issued laptops. The figures for school-issued tablets are 21 percent (Grades 6–8) and 14 percent (Grades 9–12).

Although lower SES families may have high access to the Internet, the quality of access may vary considerably according to a study carried out by the Joan Ganz Cooney Center at Sesame Workshop of 1,991 families living below the median income level (Rideout & Katz, 2016). In the words of the study's authors: "Many [lower income] families face limitations in the form of service cutoffs, slow service, older technology, or difficulty using equipment because too many people are sharing devices"(p. 10). For example, nearly a third of these families rely solely on mobile access. And among these, roughly a quarter reported having service cutoff, nearly 30 percent said that they have hit limits on the amount of service available given their service plans, and about 20 percent indicated that there were challenges using the Internet because of the number of persons in the family sharing the mobile device.

Student Familiarity With Technology

Compared with access to technology, there appear to be significantly fewer studies that have examined student familiarity with technology indirectly, and none that have examined it directly, including its relationship to taking a test on a digital device.

The TRU study, mentioned briefly above, is a national online survey of 1,000 sixth, seventh, and eighth graders (i.e., middle school students), which was carried out by Verizon in the fall of 2012 (Sarmiento & Glauber, 2012). The study does not purport to examine familiarity, but its findings clearly are related to it. For example, the study found that 64 percent of students had used a laptop to complete homework assignments and nearly 45 percent did so on at least a weekly basis. Use and its frequency are logically related to familiarity. Also, nearly 40 percent of students had used smartphones to do homework. Interestingly, the study also revealed that more Hispanics (38 percent) and African Americans (27 percent) reported using their smartphones for doing homework on a weekly basis or more than did White students (24 percent). The figures for tablet use for homework on a weekly basis or more follow the same pattern—Hispanics (32 percent), Blacks (26 percent), and Whites (24 percent). Roughly half of those who reported using tablets in class said they bring their own devices to school. The TRU study also found that not all schools encourage the use of technology: 66 percent of students reported that they were not allowed to use tablets in class, and 88 percent were not allowed to use smartphones.

A couple of things about the TRU survey need to be noted. First, the survey was conducted online, which means that the sample was biased toward those who had online access. That is, it was not a random sample of students. Second, a quota sample based on household income was used to ensure that low-income students were included and that the male-female distribution was 50-50. However, it appears that quotas were not used for race/ethnicity. For these reasons, it is not certain how much weight to put on the results of the study.

A second, somewhat relevant study was carried out by the Kaiser Family Foundation (Rideout, Foehr, & Roberts, 2010). It examined media use by 8- to 18-year-olds in 1999, 2004, and 2009 using representative national samples. As might be expected given the explosion in technology in the United States, media use in general was up for all groups of children from 1999 to 2009. Computer and Internet use were part of the definition of media use in their study, but only one question dealt with the use of computers for schoolwork and, unfortunately, the results were not broken out by race/ethnicity or family SES. Interestingly, the study found that total computer use (as well as all media use when it was summed together) was highest among Blacks, followed by Hispanics; White children reported the lowest amount of use. Although these results suggest that minority children in 2009 were more likely to use media than White children overall, the study unfortunately does not tell us anything about how these groups used technology for schoolwork.

Using a different but relevant measure of familiarity, teachers in the 2017 Project Tomorrow study reported that 50 percent of students in Grades 6–8 and 49 percent of those in Grades 9–12 reported taking tests online.

In summary, no studies could be found that measured familiarity with technology directly. The TRU study indicates that significant percentages of students use computers, tablets, and smartphones in doing their schoolwork and homework. One of the interesting findings of the Kaiser Family Foundation study was that Blacks had the highest computer use, followed by Hispanics and then Whites. Also of interest was the 2017 Project Tomorrow findings that about 50 percent of students had taken a test online in middle and high school.

Digital Technology Versus the Use of Paper and Pencil for Test Taking

The jury is out on the effects of a DBA versus a PBA in assessing performance. As reported in a recent comprehensive review of the literature by the Council of Chief State School Officers (CCSSO; DePascale, Dadey, & Lyons, 2016), recent meta-analyses have shown mode effects to be either small or nonsignificant (Kingston, 2009; Wang, Jiao, Young, Brooks, & Olson, 2007, 2008). The CCSSO report goes on to note, however, that some of the studies suggest that taking tests using digital technology may disadvantage at least some students, and the differences may vary by content area. More specifically, they note that when differences were found, those taking the test using digital technology were more likely to score higher when taking an English language arts or social science test, and those taking a mathematics test did better when taking it by paper and pencil. A study by PARCC, as discussed in an *Education Week* blog (Herold, June 10, 2016), reports that of the roughly 5 million students who took the 2014–15 PARCC assessment, students who took the assessments on the computer did worse, on average, than those who took it with paper and pencil.

In recent years two sets of experiments have been undertaken comparing student performance depending upon whether notetaking is done on a laptop versus paper and pencil. One was an introductory economics study at the U.S. Military Academy at West Point (Carter, Greenberg, & Walker, 2017). Using a randomized controlled design, the cadets were assigned to one of two treatment conditions or to a control condition. One of the treatment conditions was assignment that permitted students to use laptops or tablets without any restrictions; a second treatment group assigned cadets to classrooms that permitted the use of tablets, but they had to remain flat on their desks. Those assigned to the control group were not allowed to use either. There was no statistical difference in final grades in the course for those in either of the treatment conditions, but both those groups received lower grades than those not allowed to use either tablets or computers in class. A second study reported the results of three experiments carried out at Princeton and the University of California-Los Angeles that further calls into question the use of laptops for notetaking (Mueller & Oppenheimer, 2014). In this series of experiments, students either took lecture notes on a computer or using a notebook and pen. The results showed that although student performance was unrelated to mode of notetaking for factual questions, students did worse on questions that required conceptual understanding when students took notes on a laptop. The studies found that students on computers take more verbatim notes; as a result, students may spend less time processing and thinking about the information they are receiving than those taking notes with pen and notebook. Those taking notes with pen and notebook appear to better grasp the most salient points contained in the lectures than those using a laptop for notetaking.

In summary, the evidence is that that some students seem to do better when taking a test using paper and pencil rather than taking it on a digital device, while other students appear to do better when taking tests using a digital device. Also, there is some evidence that there may be an interaction with the content being tested as well as whether factual rather than conceptual knowledge is being assessed.

The Use of Tablets Versus Computers for Test Taking

In a report issued by PARCC in 2016 (Steedle, McBride, Johnson, & Keng, 2016) that focused on a device comparability study conducted in 2015, the authors reported that, overall, there were no significant differences in test results whether students used a computer or a tablet. In spite of that general conclusion, PARCC reported that students taking the algebra and geometry exams did more poorly when the test was taken on a tablet rather than on a computer. For example, PARCC found that at Grade 4, about 37 percent of the mathematics items were more difficult for students when taken on a tablet rather than on a computer.

Steedle and colleagues also reported a rather dramatic set of results for Ohio where students did significantly worse when taking the test on a tablet rather than on a computer. It was reported in the June 10, 2016, *Education Week* blogs (Herold, June 10, 2016) that PARCC viewed the Ohio results as atypical and, as a result, excluded them from their overall reporting of results.

At this point in time, Smarter Balanced has not released results from their study on mode effects, although they reported to *Education Week* (Herold, June 10, 2016) that their tests were providing about the same information on students' knowledge and skills regardless of whether students used a tablet "or other eligible device." The CCSSO report referenced above cites a study by Pearson done with a sample of high school students that showed no difference between those taking tests on a computer compared with a tablet, and this was true regardless of content area and item type. Furthermore, a study from Renaissance Learning on its STAR exams, also discussed in the CCSSO report, found some interactions with content depending upon whether the test was taken on a computer versus a tablet.

Not unlike the impact of taking a test on a computer versus paper and pencil, a review of results on the impact on test results of taking a test on a computer versus taking it on a tablet is mixed. Some studies show no difference, but others indicate that students taking the test on a tablet do worse than those taking it on a computer. Yet, other studies show there may be an interaction with content, where those taking a mathematics test on a tablet do worse than those taking it on a computer.

Summary

Digital testing has been around for several years, but it has only been in the past few years that states have begun to use it. As indicated, NAEP has done some online testing as well in recent years but is set to become all digital beginning with the 2017 assessment. One of the concerns as NAEP moves to an all-digital assessment is the degree to which students taking it may have differential access to and familiarity with digital technology, and whether access and familiarity, in turn, may be related to NAEP performance.

The best and most recent literature suggests that technology has and continues to make its way not only into a very high percentage of homes, but also in schools and within schools across most grades. Findings indicate that a high percentage of all students have access to digital technology, though there is some variation by SES and race/ethnicity.

In contrast, we know almost nothing about students' familiarity (or device fluency) with digital technology and whether it varies by student characteristics, such as SES and/or race/ethnicity. Also, we know nothing about how familiarity relates to test performance. Cleary, access does not presume degree of familiarity. It is for this reason that Lorié (2015), cited in the CCSSO study, appeals for more research on the relationship between what he calls "device fluencies" and test performance. In a similar vein, a recent *Education Week* blog suggests that the mode differences observed may have to do "more with their familiarity with technology than with their academic knowledge and skills" (Herold, February 4, 2016).

It is for these reasons that it is important to undertake a study that examines the role of both access to and familiarity with student test performance on NAEP, and whether access and familiarity are differentially distributed on the basis of important student characteristics.

Data

Administration of the survey for this study was carried out by Westat as an adjunct to the operational 2015 NAEP administration in Grades 4, 8, and 12 in mathematics reading, and science. The sampling was designed to select equivalent samples of schools that were administered NAEP in the DBA and PBA modes with a minimum of 2,000 students per grade per mode equally divided across the three subjects (i.e., a minimum of about 667 students per subject area, grade, and mode). The actual numbers of students administered the survey by grade, subject, and mode are provided in Appendix A.

Multiple imputation techniques (Asparouhov & Muthén, 2010) were used to create complete student records for this study's survey items using Mplus. Students sampled did not always answer every item on the survey; however, for our intended analysis, partially complete records are not usable and would otherwise need to be dropped. In order to use the maximum number of student observations feasible, we employed multiple imputation techniques to populate missing values in partially complete records. Five imputed datasets were generated with missing responses imputed based on student demographic characteristics (gender, race/ethnicity, National School Lunch Program (NSLP) eligibility, student with disability status, and English language learner status) in addition to responses to the survey questions. Any subsequent analyses were conducted using the five imputed datasets.

Ultimately, we did have to drop some student records. First, at the time that we conducted the analysis, science assessment scores (plausible values) were not available, so students who took the science assessment were excluded from the analysis. Second, students missing major contextual demographic information were excluded from the analysis. Student contextual demographic information was important because the results were compared across major reporting subgroups. In addition, we dropped students who answered *none* of the items on the study's digital technology-related contextual survey items. The numbers of students contained in our analysis are reported in Table 1.

Table 1. Analytic Sample Size for Each Grade by Mode and Subject

	Grade 4		Grade 8		Grade 12	
Subject	**PBA**	**DBA**	**PBA**	**DBA**	**PBA**	**DBA**
Math	1,000	600	1,300	500	1,100	500
Reading	1,100	600	1,400	800	1,600	700
Total by mode	2,100	1,300	2,700	1,300	2,600	1,200
Total	**3,300**		**4,000**		**3,800**	

NOTE: Students who took the science assessment were excluded from the analysis. Students without demographic information (sex, race, NSLP eligibility status, student with disability status, and English language learner status) or those who did not answer any of the study's contextual survey items were excluded from the analytic sample (approximately 100 at Grade 4, 70 at Grade 8, and 60 at Grade 12). Numbers are rounded to the nearest 10 or 100.

PBA=paper-based assessment; DBA=digitally based assessment; NSLP=National School Lunch Program.

Methodology

The student contextual questionnaire administered as part of operational NAEP collects only a limited amount of information on students' access to and use of digital technology: Students are asked only whether there is a computer in the home and whether they have access to the Internet at home. To investigate concerns related to the move to a DBA for students with low access to and familiarity with digital technology, additional items needed to be developed and administered, and responses analyzed.

For this study, we developed the survey items measuring three major domains: access to, familiarity with, and self-efficacy for digital technology. The survey was administered as a special study as part of the 2015 operational NAEP to more than 15,000 students. We then studied the responses to these survey items using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to examine the factor structure of the survey responses and hypothesized domains. Based on these results, we created indices representing constructs within each of the three domains identified and confirmed by factor analyses. We used descriptive statistics to compare the distribution of these indices across student subpopulations. Finally, regression models were used to investigate the relationship of indices with NAEP and whether there was differential validity across modes of NAEP administration.

Survey Development

One primary goal of the study was to develop measures that could be considered for inclusion in the contextual questionnaires for future NAEP assessments, with the expectation that as schools in the United States incorporate technology into learning and assessment, it will be important to have this kind of information in understanding and interpreting NAEP. The survey used in this study drew from previous studies and instruments as well as new and innovative items developed for this study. Our goal was to find or write a set of *core* items that measure computer and other digital technology access and familiarity, *especially as they relate to school-related activities (e.g., using a computer to do homework)*. In contrast, our goal was *not* to build items that examine the instructional use of computers, tablets, or other technologies *in specific content areas*. Such items, which have been administered in previous NAEP assessments, are more appropriately built by content experts.

We began this study with a focus on two major domains, access to digital technology and familiarity with digital technology, and reviewed how NAEP and other major assessments measured and/or researched these or similar domains. The NAEP assessments and research reviewed included the Mathematics Computer-Based Study (MCBS), the Technology and Engineering Literacy (TEL) assessment, and computer-based writing assessments. Given the importance of the concept of digital technology self-efficacy in the TEL study (Zhang et al., 2016), self-efficacy was added as a third domain that we probed in the survey. Other assessments and research that we reviewed included the Trends in International Mathematics and Science Study (TIMSS), the Programme for International Student Assessment (PISA) administrations, and the International Computer and Information Literacy Study (ICILS).

Based on our review of the literature, a pool of items intended to measure these three domains was identified, with a particular focus on items related to technology as it is used for school and schoolwork. From this pool of existing items, the study team selected a set that they judged to be (a) potentially appropriate for measuring one of the three domains and (b) appropriate for administration at all three grade levels. Only a relatively few items were judged to be useful. The set of existing items was reviewed by experts from the NVS Panel and ETS, and adapted as necessary.

Based on perceived holes and deficiencies in the set of existing items, many new items were developed for the survey. In particular, based on feedback from an Office of Management and Budget (OMB) review of the first draft of the survey, new blocks of items were added. OMB required that we expand the familiarity items for students in Grades 8 and 12, arguing that we would otherwise be seriously underestimating the familiarity that these students had with digital technologies and their applications.

In writing the final set of items for Grades 8 and 12, we worried that some students might claim familiarity with technologies with which they really did not have familiarity. Based on previous work (Kyllonen & Bertling, 2013), an innovative block of items was included in the survey to measure what is called "overclaiming" in the research literature (e.g., Paulhus, Harms, Bruce, & Lysy, 2003). This block of items asked students about their level of familiarity with various digital technology concepts, such as "Wi-Fi" or "firewall," as well as an interspersed collection of foils (i.e., fictional concepts), such as "pyramidal browser" or "spinalbyte."

The basic idea behind the overclaiming technique is that students' claimed familiarity with concepts carries both information about their actual familiarity and about their typical response pattern to self-report surveys in general, specifically their tendency to overstate what they know, regardless of the topic at hand. Previous research indicates that the validity of topic familiarity measures can be improved by adjusting student self-ratings based on their claimed familiarity with a set of foil concepts (i.e., concepts that do not exist and should therefore be unfamiliar to all students, regardless of their familiarity with the actual concepts of interest). In the context of PISA, for instance, the overclaiming technique was applied to derive an index of familiarity with mathematics concepts based on the 2012 student questionnaire (Kyllonen & Bertling, 2013; Organisation for Economic Co-operation and Development [OECD], 2014). For PISA, foils were developed by combining mathematical terms with linguistic terms (e.g., "subjunctive scaling"). For this study, foil concepts were created based on combining technology-related terms with terms from neuroscience. Examples of foil technologies that we presented to the students and with which they claimed familiarity included "neuro-digital computing," "limbic wire," and "spinalbyte."

The familiarity items from this innovative block as well the foils were used in this study are described below.[1] Copies of the questionnaires used at Grades 4 and 8 (the Grade 12 questionnaire is identical to that used for Grade 8) are shown in Appendix B.

Answering the Research Questions

To answer research question 1, we used EFA to probe the underlying factor structure of the whole questionnaire and, more relevantly, within each of the three domains: access to, familiarity with, and self-efficacy for digital technology. EFAs were conducted separately for each of the three grade levels with two subjects (mathematics and reading) and both modes (PBA and DBA) combined. Analyses were conducted using Mplus with oblique rotation (i.e., allowing factors to correlate).

Although the vast majority of items used in this study's survey were common across all grades (the "common set"), there were additional items included on both the Grade 8 and 12 surveys. EFAs at Grades 8 and 12 were conducted both with just the common set as well with the additional items (the "full set").

We next used CFA to confirm the factor structure identified based on the EFA results. CFAs were conducted for both the common and full sets of items at Grades 8 and 12, and the internal consistency reliabilities of factors in each domain for both the common and full sets were examined for all grades.

To answer research question 2 and subsequent research questions, we created indices for each of the factors identified and verified by factor analyses. To construct these indices, we averaged responses across items in each factor and standardized each index across all students by grade to have a mean of 50 and standard deviation of 10.

The index to measure home access includes items that measure the availability of digital devices (computer/laptop, tablet, smartphone) as well as access to the Internet. The school access index includes measures of the availability of digital devices in the classroom (computer/laptop, tablet) and access to the Internet.[2]

[1] An additional block of items developed by Jonas Bertling was included in the Grade 8 and 12 surveys but was not used in the analysis presented here. This block used a series of vignettes to provide grounding for interpreting a student's self-reported overall familiarity with computers and other digital devices.

[2] Some readers might be interested in the item-level responses in order to compare them with the findings from other surveys reported in the literature review. Readers interested in these results, both

The four indices in the familiarity domain focus on potential uses of digital technology for learning. The familiarity through instruction index includes items that asked if the student had been taught in school ("yes" or "no") various activities using digital devices, such as how to type, write, and edit a document; how to create a spreadsheet, presentation, graph or chart, website or blog; how write a computer program; and how to troubleshoot problems. The familiarity through computer/laptop use index includes items that ask students about how often they used such a device (using five response categories ranging from "never" to "more than once a week") for school-related activities, such as writing papers, searching the Internet for a project, practicing math or reading, taking a test, or creating a map, website, blog, or presentation. The familiarity through tablet use index includes items that asked how often the student did those same things on a tablet. The familiarity with digital concepts index, which was used at Grades 8 and 12 only, included items that asked how familiar (using four response categories ranging from "never heard of it" to "know it well, understand the concept") the student was with various digital concepts, including e-reader, firewall, hyperlink, instant messaging, CPU, track changes, pivot table, spreadsheet, cloud computing, server, root directory, compiler, and ASCII. For this index, the process for scoring was slightly different in order to implement the overclaiming technique. Here, a student's average reported familiarity with foil concepts was subtracted from his/her average reported familiarity with the real concepts to provide an adjusted familiarity index. The adjusted familiarity index was then standardized across students.[3]

The self-efficacy index includes items that asked the student about his/her ability (using four response categories ranging from "I definitely can't" to "I definitely can") to perform certain tasks on a computer, including writing and editing text, using a touchscreen, looking up the meaning of a word, drawing a picture, downloading media, creating a presentation, creating a spreadsheet, installing software, using social media, maintaining a website or blog, searching for information, running simulations, creating a graph or chart, writing a program, and figuring out how to use new functions.

To investigate research question 2, we compared the means of each of the indices across major subgroups using the combined PBA and DBA mathematics and reading samples:

- Females compared with males,
- Non-White racial/ethnic group students compared with White students,
- NSLP-eligible students compared with noneligible students,
- Students with disabilities compared with students without disabilities, and
- English language learners (ELLs) compared with non-ELLs.

overall and broken out by subgroup, can find them in Appendix C. In addition, a separate report that examines the item-level data, overall and by subgroup, is in development and will be released as a separate NAEP Validity Studies Panel report.

3 In preliminary work for this report, analysis was conducted with separate familiarity with digital concepts indices: one for familiarity with the real concepts and one for familiarity with the foil concepts. In this report, however, we only present analysis using the "corrected" familiarity with digital concepts index.

In order to assess substantial differences across subgroups, we first tested differences in mean indices across subgroups for statistical significance. However, we were interested in differences that were meaningful in magnitude and subsequently defined this as equal to or greater than a 2-point difference. Given that the indices were designed to have a standard deviation of 10, the 2-point threshold marks a difference in means equal to or greater than 0.2 standard deviations.[4] This definition of substantive significance may be a bit on the conservative side, but for the purposes of this study it was better to err on the conservative side rather than risk missing what may be some small, but important results when looking at patterns of findings across major subgroups.

Research questions 3 and 4 inquire about the relationships between digital technology access, familiarity, and self-efficacy. To examine these, we used a regression framework. Research questions 3 and 4 were addressed using a simple regression model, with NAEP scores as the dependent variable and one index at a time as the sole independent variable (Equation 1).

Equation 1.

$$NAEPScore_i = \beta_0 + \beta_1 Index_i + \varepsilon_i$$

The coefficient of interest here is β_1, which is interpreted as "the increase in NAEP score associated with a 1-point (i.e., 1/10 of a standard deviation) increase in the index."

Equation 1 was estimated separately by subject for reading and mathematics. Equation 1 also was estimated separately for each mode, PBA and DBA. For research question 3, the direction and significance of β_1 in the DBA sample was the focus. For research question 4, the difference between the estimates for the DBA and PBA samples was the focus: $\beta_1^{DBA} - \beta_1^{PBA}$.

To address research question 5, the regression model used for research questions 3 and 4 was expanded to include demographics, including gender, race/ethnicity, ELL status, student with disability status, NSLP eligibility, and school locale type. Our main interest in using these variables was to control for SES; however, though the DBA and PBA samples were drawn to be randomly equivalent, in practice there were slight differences in them. Hence, we included more than just indicators of SES in the model. The intent of the research question is to examine the extent to which any patterns found or conclusions reached in the analysis for research question 4 are robust when accounting for potential confounding variables.

Equation 2.

$$\begin{aligned} NAEPScore_i = {} & \beta_0 + \beta_1 Index_i + \beta_2 Female_i + \beta_2 Black_i + \beta_2 Hispanic_i \\ & + \beta_2 Asian_i + \beta_2 Other_i + \beta_2 NSLPeligible_i + \beta_2 ELL_i + \beta_2 SD_i \\ & + \beta_2 City_i + \beta_2 Town_i + \beta_2 Rural_i + \varepsilon_i \end{aligned}$$

[4] There is no agreed-upon criterion for deciding what is substantively significant or not. Cohen (1988) defines an effect size of 0.2 as small and 0.5 as medium.

In this expanded model (Equation 2), the coefficient of interest was again β_1 and, more specifically, the difference between the estimate for the DBA and the PBA samples, $\beta_1^{DBA} - \beta_1^{PBA}$, to compare results with those reported for research question 4.

All analyses for answering research questions 2 to 5 were conducted in Mplus using the "type=imputation" command, which averages the parameter estimates over the five imputed datasets and calculates proper standard errors accounting for using multiple datasets. Because the data we received did not include weight variables (e.g., student weights and replicate weights), accurate standard errors accounting for the sampling errors needed to be approximated. Unfortunately, based on the information available in the data we had, we were not able to make appropriate adjustments. But the variances of all estimated parameters related to student performance were adjusted by a factor of 2.0 to account for measurement errors given the achievement scores (i.e., plausible values) and were averaged for the regression analysis.[5] Because of this the estimates should be interpreted and generalized to the overall population with caution.

Results

Research question 1. Do the access, familiarity, and self-efficacy items cluster together in ways that suggest that reliable indices of each can be constructed?

Exploratory Factor Analysis (EFA)

Using EFA, we examined the dimensionality of the domains, potential groupings of items into different factors, and potential items to drop from the analysis. EFA results indicated that each domain was potentially multidimensional; hence, we investigated solutions with multiple dimensions for each. Considering the model fit, interpretability of the resulting factors, minimizing instances of loadings across multiple factors, and seeking parsimony where possible, our final EFA settled on the following factors for each domain:

- In the access domain, we identified two dominant factors that we interpreted as "access at home" and "access at school";
- In the familiarity domain, we identified three dominant factors across all grades that we interpreted as "familiarity through instruction," "familiarity through computer use," and "familiarity through tablet use," and two additional factors at Grades 8 and 12, "familiarity with digital concepts" and "overclaiming"; and
- In the self-efficacy domain, we identified one dominant factor that we interpreted as "self-efficacy with digital technology."

[5] A previous study shows that adjusting parameter variance by a factor of 2 can adequately address the variance underestimation issue (Broer, Park, Bohrnstedt, & Kim, 2015). However, the results should be interpreted with a caution as this is an approximation and the proper adjustment factor could vary depending on the assessment.

Internal consistency reliabilities for each of the factors identified from the EFA were examined (Cronbach, 1951). In addition, each item's response frequency was examined for the skewness of distribution. Using all of these analyses, several items were deleted and the final selection of items was made.

EFA factor loadings as well as the CFA loadings for the common set of items used in the final analyses are provided in Appendix D. (EFA loadings across all domains are available from the authors upon request.) CFA loadings for the full set of items for Grades 8 and 12 are provided in Appendix E.

The fit statistics from the EFA analyses with the items are shown in Table 2.

Table 2. Exploratory Factor Analysis Model Fit Statistics

	Grade 4	Grade 8	Grade 12
Access			
RMSEA	0.05	0.02	0.02
CFI	0.95	0.98	0.99
TLI	0.87	0.96	0.96
Familiarity			
RMSEA	0.07	0.06	0.06
CFI	0.90	0.92	0.91
TLI	0.87	0.90	0.90
Self-Efficacy			
RMSEA	0.07	0.14	0.12
CFI	0.99	0.89	0.92
TLI	0.97	0.87	0.93

NOTE: The entries for self-efficacy are the same as those in Table 3. Because a single factor fit the self-efficacy items, fit statistics and factor loadings were identical for both EFA and CFA.

RMSEA=Root Mean Square Error of Approximation; CFI=Comparative Fit Index; TLI=Tucker-Lewis Index.

Confirmatory Factor Analysis

Using the final selection of items and factors within each domain, results from the CFA indicate weak evidence for building reliable indices in the access domain but more optimistic results for the familiarity and self-efficacy domains. First, looking at model fit statistics, the two-factor solution for the access domain had RMSEA (Root Mean Square Error of Approximation), CFI (Comparative Fit Index), and TLI (Tucker-Lewis Index) fit statistics (Table 3) that met standard criteria for a "good" model fit.[6] In the familiarity and self-efficacy domains, the fit statistics met or were close to meeting the criteria. Interestingly, in these domains the set of items common with Grade 4 generally fit better than the full set of items, indicating that a smaller set of items may be adequate.

[6] For the Comparative Fit Index and Tucker-Lewis Index, values of .90 or greater are considered good fits (Hu & Bentler, 1999).

Table 3. Confirmatory Factor Analysis Model Fit Statistics

	Grade 4	Grade 8		Grade 12	
	Common Set	Common Set	Full Set	Common Set	Full Set
Access					
RMSEA	0.04	0.02	n/a	0.03	n/a
CFI	0.95	0.97	n/a	0.96	n/a
TLI	0.92	0.96	n/a	0.93	n/a
Familiarity					
RMSEA	0.08	0.06	0.07	0.07	0.07
CFI	0.89	0.95	0.90	0.92	0.88
TLI	0.88	0.95	0.89	0.91	0.87
Self-Efficacy					
RMSEA	0.07	0.09	0.14	0.04	0.12
CFI	0.99	0.99	0.89	1.00	0.93
TLI	0.97	0.99	0.87	1.00	0.92

NOTE: RMSEA=Root Mean Square Error of Approximation; CFI=Comparative Fit Index; TLI=Tucker-Lewis Index.

As indicated in the Methodology section, the results from the factor analyses were used to construct indices for each of the factors. Although the fit statistics in Table 3 indicated that the model fit the access domain well, the reliabilities (Cronbach, 1951) associated with the two indices that represent this domain, access at home and access at school, were low (see the last row in Tables 4–6).[7] For example, the reliabilities for home access range from 0.35 to 0.43 for Grades 4, 8, and 12; similar figures for school access range from 0.35 to 0.39—all well below the 0.70 level, which is generally considered acceptable. In contrast, the indices built for the familiarity domain and the one for the self-efficacy factor all have acceptable to very good reliabilities. The tables also show that the indices are low to only moderately correlated with each other; the highest correlations being from 0.37 to 0.46 (by grade level) for familiarity through computer use and familiarity through tablet use.

Even though the reliability coefficients were lower than desired in the access domain, we decided to build the indices regardless. There were two justifications for doing so. First, as noted above, the fit statistics for CFA results were excellent. Second, home access and school access were comprised of only four and three items, respectively, and internal consistency reliability is partially a function of the number of items. Please note that results based on these two measures should be treated with caution.

[7] A reliability at or above 0.70 generally is considered acceptable.

Table 4. Computer Access and Familiarity Indices Correlations and Reliability: Grade 4 Common Set

	Access		Familiarity			
	Home Access	**School Access**	**Instruction**	**Computer Use**	**Tablet Use**	**Self-Efficacy**
Home Access	1.00					
School Access	0.14	1.00				
Instruction	0.12	0.27	1.00			
Computer Use	0.18	0.30	0.26	1.00		
Tablet Use	0.17	0.37	0.23	0.46	1.00	
Self-Efficacy	0.18	0.13	0.19	0.15	-0.01	1.00
Reliability	0.43	0.39	0.63	0.74	0.85	0.73

Table 5. Computer Access and Familiarity Indices Correlations and Reliability: Grade 8 Common Set

	Access		Familiarity				
	Home Access	**School Access**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Self-Efficacy**
Home Access	1.00						
School Access	0.03	1.00					
Instruction	0.05	0.15	1.00				
Computer Use	0.08	0.28	0.16	1.00			
Tablet Use	0.05	0.29	0.10	0.40	1.00		
Concept	0.09	-0.07	0.04	-0.03	-0.17	1.00	
Self-Efficacy	0.14	-0.03	0.07	0.09	-0.09	0.30	1.00
Reliability	0.35	0.35	0.72	0.80	0.91	0.89	0.84

Table 6. Computer Access and Familiarity Indices Correlations and Reliability: Grade 12 Common Set

	Access		Familiarity				
	Home Access	**School Access**	**Home Access**	**School Access**	**Home Access**	**School Access**	**Self-Efficacy**
Home Access	1.00						
School Access	0.04	1.00					
Instruction	0.02	0.14	1.00				
Computer Use	0.05	0.21	0.11	1.00			
Tablet Use	0.05	0.18	0.11	0.37	1.00		
Concept	0.07	-0.03	-0.01	-0.02	-0.20	1.00	
Self-Efficacy	0.13	-0.01	0.02	0.08	-0.15	0.32	1.00
Reliability	0.40	0.37	0.74	0.79	0.92	0.88	0.89

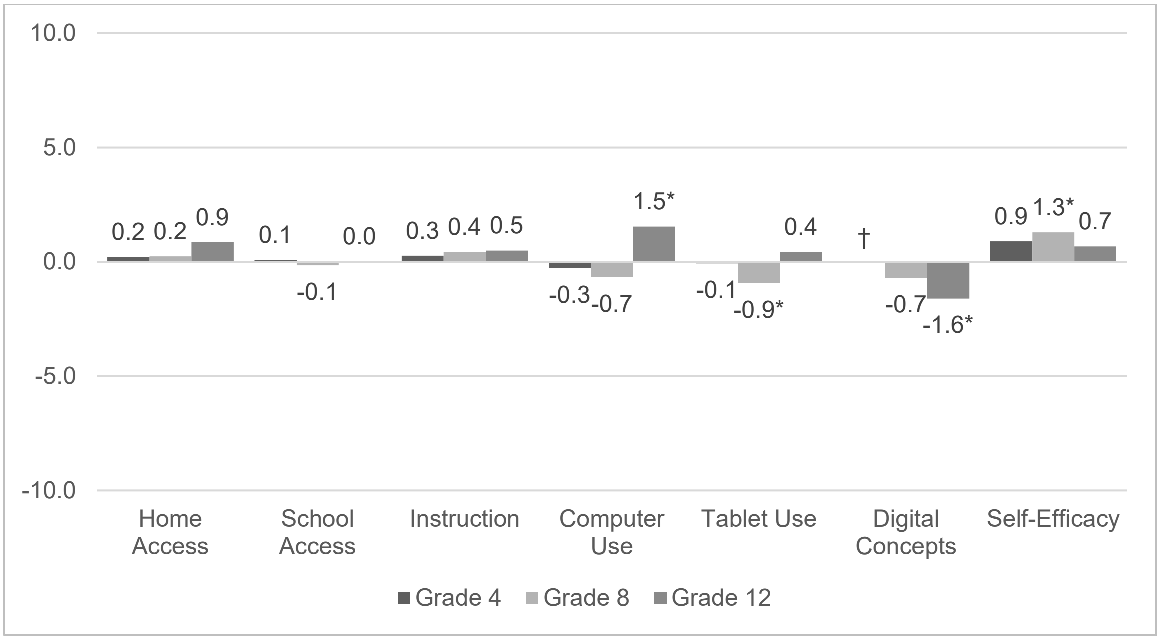
In summary, for research question 1, in examining the access and familiarity domains, both constructs were found to be multidimensional. These two domains were best measured using indices to measure the following subdomains: access at home and at school; and familiarity through computer/laptop use, through tablet use, through instruction, and with digital concepts (Grades 8 and 12 only). In contrast, a single-factor model best described the digital self-efficacy domain. We found that our proposed multiple-factor structure fits the data well in each of the domains. The reliabilities of indices developed from the factors for the familiarity and self-efficacy domains were good to very good; however, the reliabilities of the two access factors were not in a range that researchers consider acceptable. When examining the results using the two access indices in the results reported below, caution against overinterpretation is advised. Finally, the correlations among the access and familiarity indices were low to moderate in size, suggesting the relative independence of the scores from one another.

Research question 2. Are access, familiarity, and self-efficacy differentially distributed across gender, race/ethnicity and/or socioeconomic status?

Our hypotheses were that we would not find many, if any, differences by gender, but would find that traditionally disadvantaged students (Blacks, Hispanics, students with disabilities, ELLs, and NSLP-eligible students), who generally have fewer opportunities to learn, also would have less home and school access to digital technology. We also hypothesized that these same disadvantaged groups would indicate less familiarity with digital technology through computer and tablet use, show less familiarity with digital concepts, and have lower digital self-efficacy than their more advantaged counterparts.

Gender. As hypothesized, there were no substantial differences between males and females. There were a few statistically significant differences in mean indices between females and males, but none met the two-index-point criterion (Figure 1). Also, the differences found were neither consistent across domains nor grade levels. (The differences were computed by subtracting the male average from the female average. That is, positive scores mean that females scored higher than males for that index.)

Figure 1. Differences in Mean Indices for Females Compared With Males (female student average – male student average)



† Not applicable.

* Statistically significant, *p* <.05.

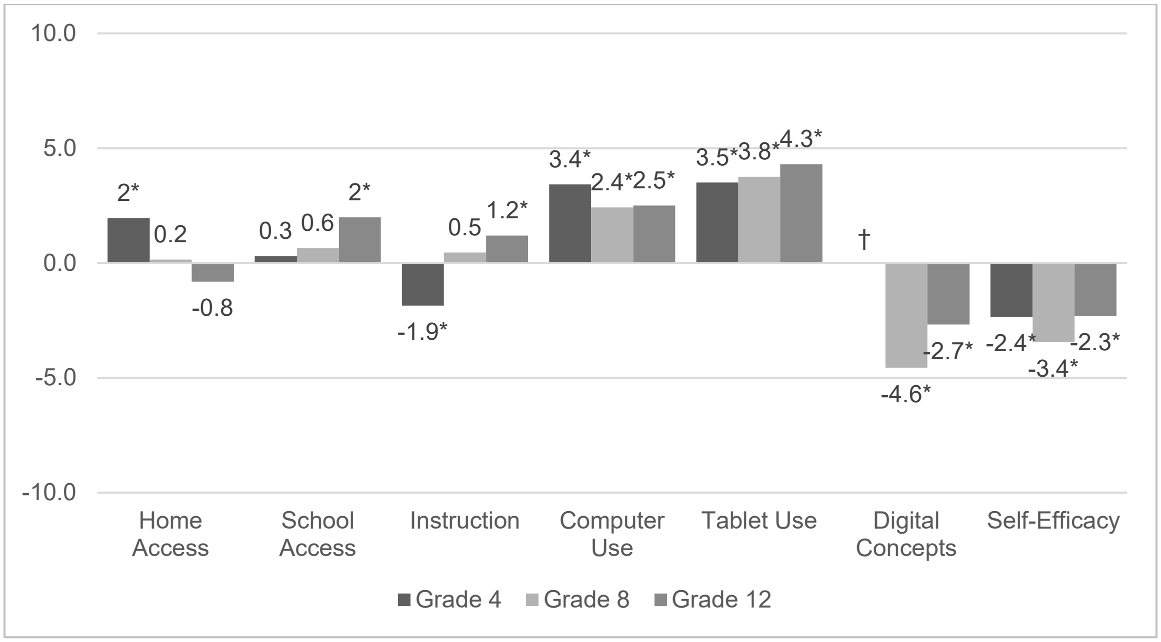
Race/ethnicity. When looking at race/ethnicity categories, positive score differences indicate that Black (or Hispanic or Asian) students reported higher on the index than White students.

Black students (Figure 2) at all three grade levels were more likely to indicate that they had gained familiarity with digital technology through the use of computers, especially through tablet use, compared with White students—a finding that is contrary to our hypothesis. At Grades 8 and 12, they indicated significantly less familiarity with digital concepts and less digital self-efficacy (at all three grade levels) compared with White students, which was hypothesized.

Consistent with our hypothesis, Hispanic students (Figure 3) reported less familiarity through instruction than White students, but only at Grade 4. However, contrary to our hypothesis, Hispanic students indicated more familiarity with digital technology through the use of tablets than White students, but only at Grade 12. Finally, as hypothesized, Hispanic students indicated substantially lower digital self-efficacy (Grades 8 and 12) and less familiarity with digital concepts (Grades 4 and 8) than White students.

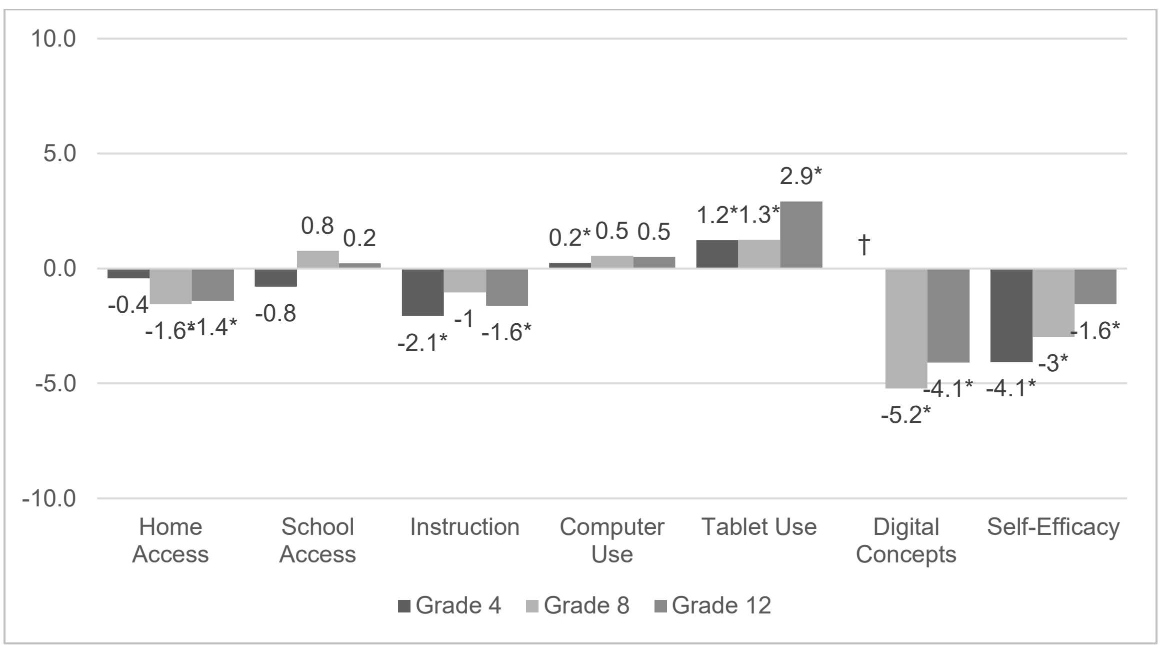
For Asian students (Figure 4), the only consistent difference from White students was that they reported less familiarity through instruction (Grades 8 and 12). Somewhat puzzling is the finding that Asian students at Grade 4 reported less familiarity with digital technology through computer use than White students, whereas at Grade 12 the result is in the opposite direction—Grade 12 Asian students reported more familiarity through computer use than White students.

Figure 2. Significant Differences in Mean Indices for Black Students Compared With White Students (Black – White)



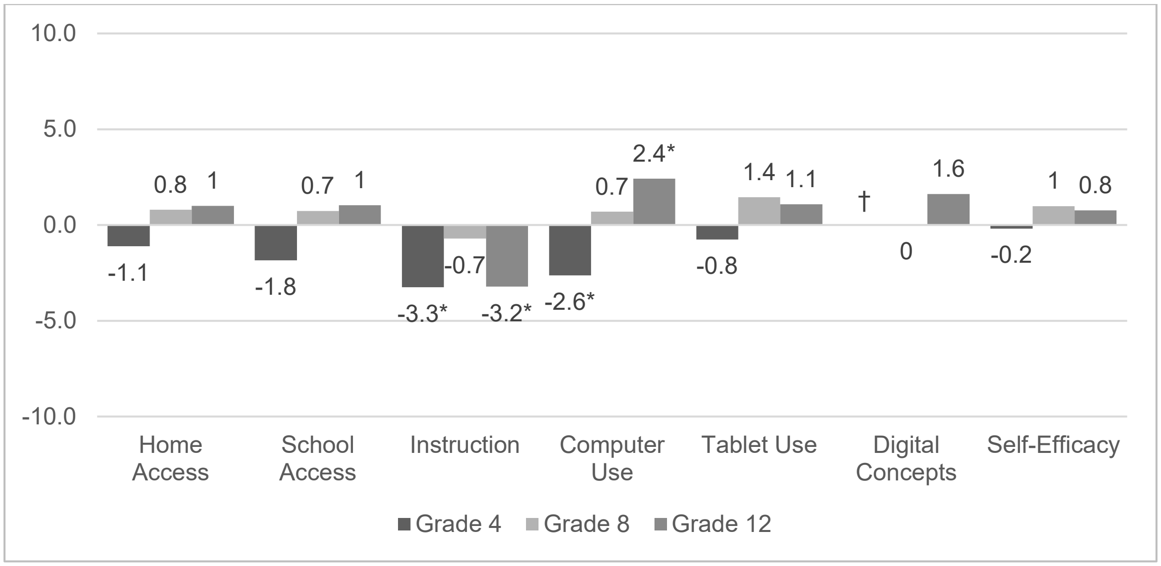
† Not applicable.
* Statistically significant, *p* <.05.

Figure 3. Significant Differences in Mean Indices for Hispanic Students Compared With White Students (Hispanic – White)



† Not applicable.
* Statistically significant, *p* <.05.

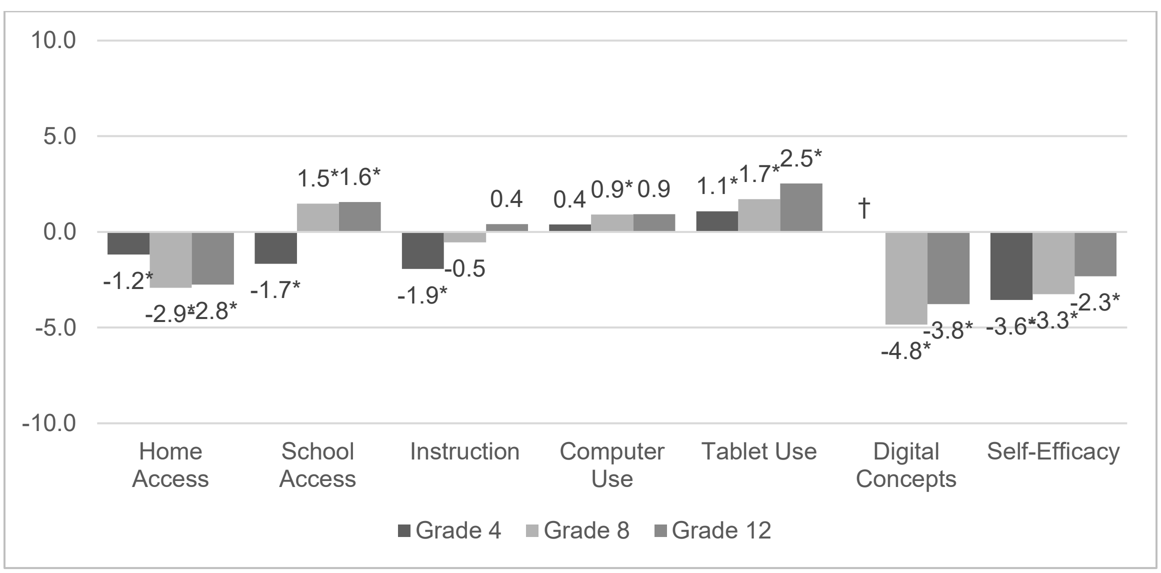
Figure 4. Significant Differences in Mean Indices for Asian Students Compared With White Students (Asian – White)



† Not applicable.
* Statistically significant, *p* <.05.

NSLP eligibility. As hypothesized, NSLP-eligible students (Figure 5) reported less home access to computers at Grades 8 and 12 than non-NSLP-eligible students. However, although not hypothesized, NSLP-eligible students at Grade 12 reported more familiarity with digital technology through tablet use than non-NSLP-eligible students. The most pronounced finding, however, is lower digital self-efficacy (all grades) and less familiarity with digital concepts (Grades 8 and 12) for NSLP-eligible students than noneligible students, which is consistent with our hypothesis.

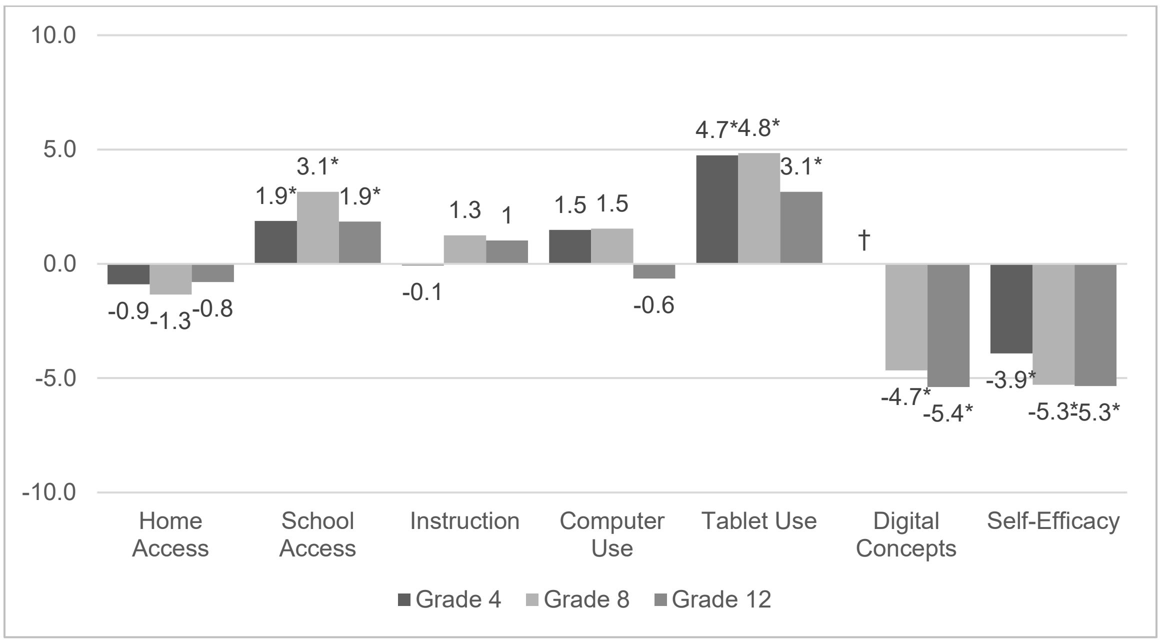
Figure 5. Significant Differences in Mean Indices for NSLP-Eligible Students Compared With Non-Eligible Students (NSLP-eligible – noneligible)



† Not applicable.
* Statistically significant, *p* <.05.

Students with disability status. Similar to the results for NSLP students, as hypothesized, students with disabilities (Figure 6) reported lower digital self-efficacy (all grades) and less familiarity with digital concepts (Grades 8 and 12) than students without disabilities. Some of these differences are substantial, nearly half of a standard deviation or more, depending upon the domain and grade level. They also exhibited more familiarity through tablet use (all grades) and greater school access to digital technology (Grade 8) than students without disabilities, which was contrary to our hypothesis.

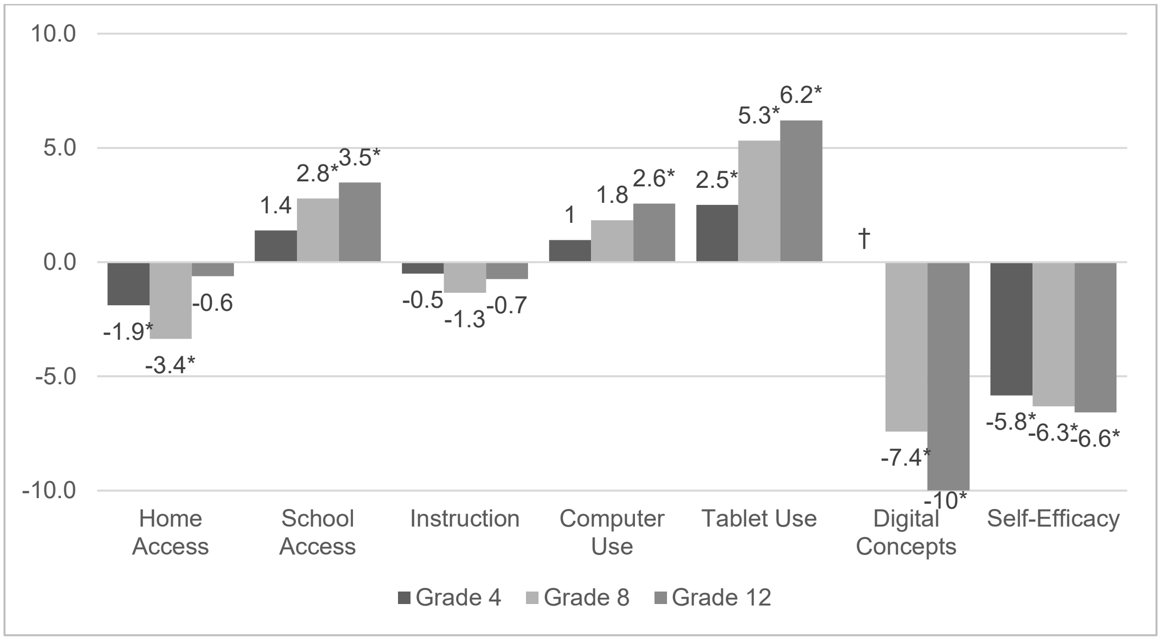
Figure 6. Significant Differences in Mean Indices for Students With Disabilities Compared With Students Without Disabilities (SD students – non-SD students)



† Not applicable.
* Statistically significant, *p* <.05.

English language learner status (ELLs). Similar to results for NSLP students and students with disabilities, as hypothesized, ELLs reported lower digital self-efficacy (all grades) and familiarity with digital concepts (Grades 8 and 12) than non-ELLs, but the differences were even larger for ELLs versus non-ELLs than for students with disabilities (Figure 7). Also, similar to results for NSLP and Black students, ELLs reported more familiarity through tablet use (all three grades). Finally, ELL students also reported less home access (Grade 8), but greater school access (Grades 8 and 12) to computers than non-ELL students, which also was hypothesized.

Figure 7. Significant Differences in Mean Indices for English Language Learner Students Compared With Non-English Language Learner Students (ELL students – non-ELL students)



† Not applicable.
* Statistically significant, *p* <.05.

In summary, for research question 2, as hypothesized, we did not find substantial differences (statistically significant and greater than 2 points/0.2 standard deviations) between male and female students. Contrary to our hypothesis, we found no evidence that Black and Hispanic students were disadvantaged because of a lack of access to digital technology either at home or at school. *Perhaps the most surprising finding was that disadvantaged students were much more likely to indicate familiarity with digital technology through the use of tablets and, to a lesser extent, through the use of computers than their more advantaged counterparts.* This is a finding to which we will return in the discussion of results. Finally, as hypothesized, we did find that disadvantaged subpopulations generally reported lower digital self-efficacy and less familiarity with digital concepts. Results are summarized in Figure 8, where the down/up arrows indicate that the subgroup had a lower/higher average than the reference group, consistent (if lower) or inconsistent (if higher) with our hypothesis, and the shading of the arrows indicates across how many grades the result was found to be substantial.

Figure 8. Summary of Comparisons of the Mean for the Subgroup Compared With the Mean for the Reference Group by Access, Familiarity, and Self-Efficacy Indices

Group	Ref Group	Home Access	School Access	Instruction	Computer Use	Tablet Use	Digital Concepts	Self-Efficacy
Female	Male							
Black	White	↑1	↑1		↑3	↑3	↓3	↓3
Hispanic	White			↓1		↑1	↓3	↓2
NSLP	Non-NSLP	↓2				↑1	↓3	↓3
SD	Non-SD		↑1			↑3	↓3	↓3
ELL	Non-ELL	↓1	↑2			↑3	↓3	↓3

↓3 = 3/all grades in hypothesized direction
↓2 = 2 of 3 grades in hypothesized direction
↓1 = 1 of 3 grades in hypothesized direction
↑1 = 1 of 3 grades in opposite direction
↑2 = 2 of 3 grades in opposite direction
↑3 = 3/all grades in opposite direction
(blank) = no substantial differences

NOTE: NSLP=National School Lunch Program; SD=students with disabilities; ELL=English language learner.

Research question 3. What is the relationship between access, familiarity, and self-efficacy, and performance on NAEP?

Using the simple regression model with no covariates, we examined the relationship between each of the indices (in separate regressions) with NAEP achievement (mathematics and reading separately). We hypothesized that indices of computer access, familiarity, and self-efficacy would be positively related to NAEP DBA scores because students with higher indices may have fewer problems and greater ease in using the new digital test platform. Hence, for these analyses, we used only the DBA to estimate the relationships between indices and NAEP performance. For addressing differential validity in research question 4 below, we will compare results in the DBA sample found here with those from the PBA sample.[8]

As seen in the results for mathematics (Figure 9) and reading (Figure 10), although estimates of home access are in the hypothesized direction, only one (reading, Grade 12) is statistically significant, and the estimates for Grade 4 are close to zero.[9]

School access, on the other hand, is found to be consistently *negatively* related to achievement at all three grade levels in mathematics and at Grade 12 in reading. For

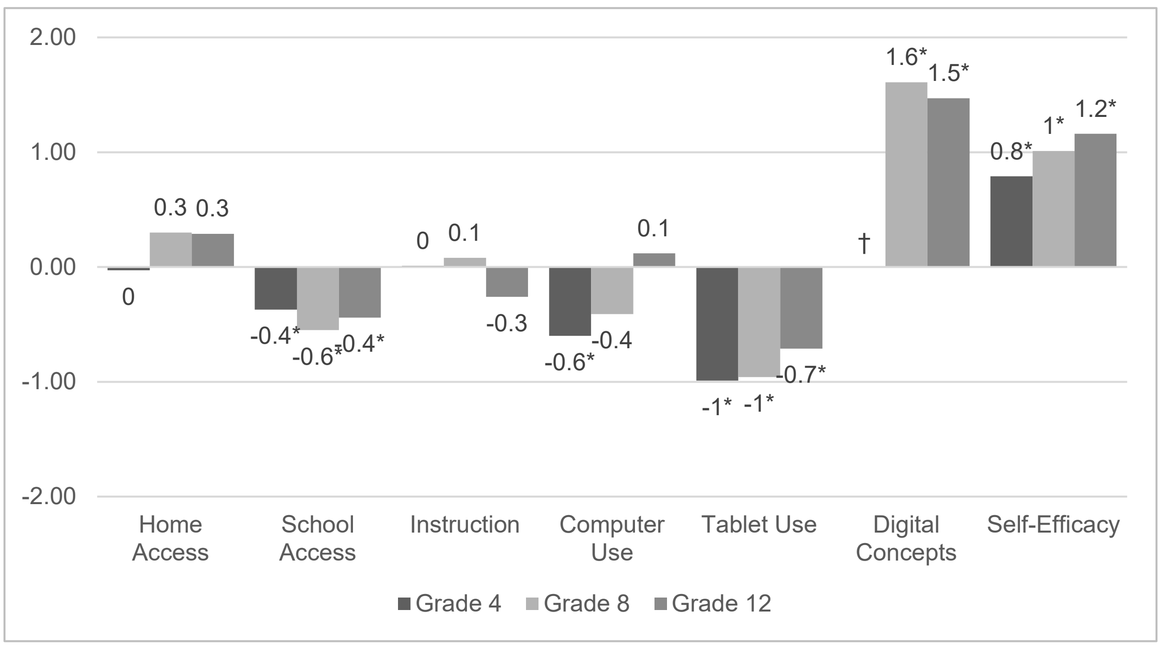
[8] Results for the DBA sample, the PBA sample, and the difference between the estimates for the two samples are presented in Appendix F.

[9] One of the primary concerns with the switch to a DBA is for students with no or little access to digital technology. We explored this issue by constructing profiles of students based on the items that make up the indices (e.g., a student with “no home access” was defined as a student who answered that he/she did not have a computer/laptop, tablet, smartphone, or Wi-Fi/Internet at home). We found that there were insufficient numbers for analysis of students in our sample who could be designated as having no or little access.

those cases where familiarity with computers and tablets was significantly related to NAEP mathematics or reading performance, all also were in the *negative* direction. *That is, having school access to technology and having familiarity through computer use and familiarity through tablet use is related to poorer, not better performance, on NAEP mathematics and reading, a finding we shall also return to in the discussion of results.* Some of these results are substantively important. For example, the -1.0 coefficient associated with tablet use in Grades 4 and 8 for both mathematics and reading means that a 1-standard deviation difference on this measure is associated with a 10-point drop in NAEP performance.[10]

More consistent with expectations are the findings that both familiarity with digital concepts and digital self-efficacy are uniformly positively related to NAEP performance, both for mathematics and reading and across grade levels. For both the familiarity with digital concepts and the self-efficacy factors, the estimates are about 1.0 or greater, which can be interpreted as a 1-standard deviation increase in either of these factors being associated with a 10-point or more increase in NAEP scores.

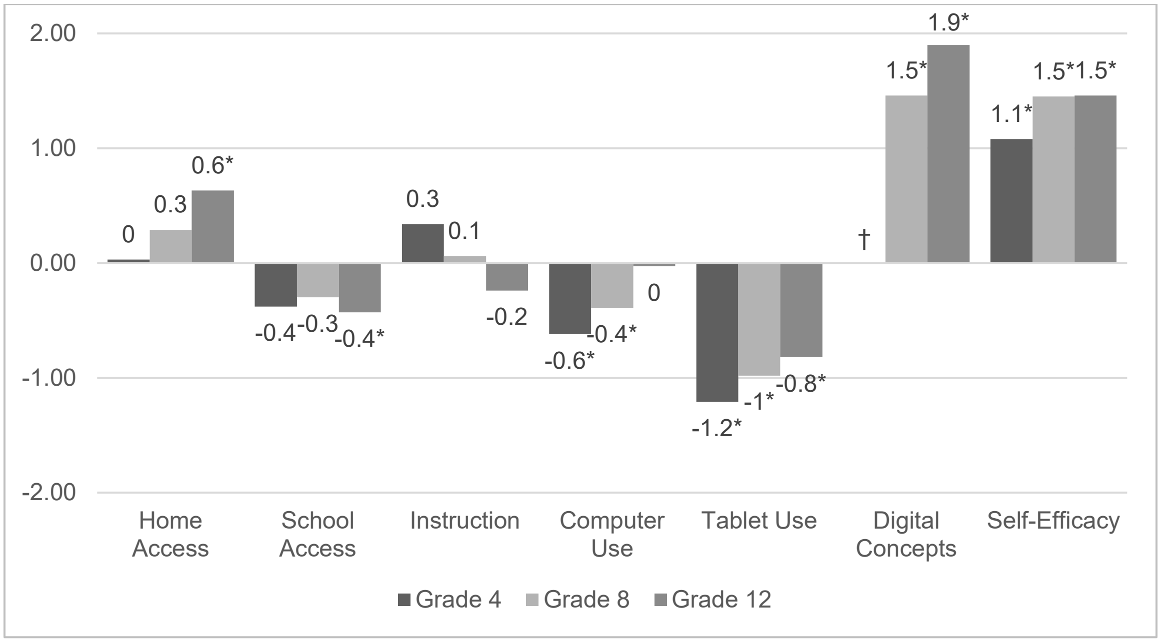
Figure 9. Regression-Estimated Relationship Between Indices and NAEP Mathematics Achievement for the DBA Sample



† Not applicable.
* Statistically significant, p <.05.

[10] With the expanded set of items at Grades 8 and 12, we were able to split the items that make up the familiarity through computer use and familiarity through tablet use indices into two groups, "basic" functions and familiarity through "advanced functions," and created four separate indices: familiarity through basic computer uses, familiarity through advanced computer uses, familiarity through basic tablet uses, and familiarity through advanced tablet uses. We found that all were negatively related to achievement using a regression framework, except for familiarity through basic computer uses. However, when conducting analysis similar to those in research questions 4 and 5, we did not find that familiarity through basic computer uses was differentially related to achievement in DBA and PBA samples, with or without demographic control variables. Results are available from the author upon request.

Figure 10. Regression-Estimated Relationship Between Indices and NAEP Reading Achievement for the DBA Sample



† Not applicable.
* Statistically significant, $p < .05$.

In summary, for research question 3, our expectation was that relationships between the indices and NAEP DBA scores would be positive. Although some indices were positively related (especially strongly related were familiarity with digital concepts and self-efficacy), others were negatively related (access at school, familiarity through computer use, familiarity through tablet use), which is a curious result that we will return to in the discussion section below.

Research question 4. Is there differential validity of the indices in predicting NAEP performance across modes of administration?

There is no reason to expect that digital access and familiarity should be related to NAEP performance in the PBA *unless* our measures are reflecting something in addition to or instead of access and familiarity (e.g., SES). Also, ideally, there would be no relationship between these measures and performance on the DBA as well—that is, the two modes are equally valid. However, if access and familiarity are important for performance on the DBA, we should see significant relationships between them and NAEP performance. Even if we find relationships between these measures and NAEP performance in the PBA, we would expect the relationships to be even stronger in the DBA sample. In order to examine research question 4, we will look at the difference in the estimated coefficients linking access and familiarity to NAEP performance in the DBA versus the PBA sample. If there is differential validity because of the importance of access and familiarity in taking the DBA, we would expect the DBA minus PBA values to be positive. If validity is not conditional on the mode used, we would expect those differences to be zero.

Looking at the differences in estimated coefficients presented for research question 3, DBA coefficients minus PBA coefficients (Table 7), we see first that there are only two significant differences across modes (school access and tablet use in Grade 4). Second, both of the significant differences are in the *opposite* direction than what we expected. There are some estimates that were positive, but the same index had a negative estimate in another grade or subject—that is, the results were not consistent across grades and subject areas. For example, the largest positive difference was for school access at Grade 8 in reading where the estimate was 0.43 and just barely insignificant (p=0.052). But school access also had one of the two *negative* and significant differences at Grade 4 in mathematics (-0.40).

Table 7. Difference in Regression Estimates of the Relationship Between Each Index and NAEP Achievement Across Modes (DBA – PBA)

	Grade 4		Grade 8		Grade 12	
	Math	**Reading**	**Math**	**Reading**	**Math**	**Reading**
Access						
Home Access	0.06	-0.08	-0.1	-0.02	0.17	0.34
School Access	-0.40 *	-0.43	-0.01	0.43	-0.04	-0.09
Familiarity						
Instruction	-0.01	0.26	0.37	0.26	0.09	0.14
Computer Use	-0.21	-0.14	-0.09	-0.09	0.14	-0.12
Tablet Use	-0.45 *	-0.48	-0.15	0.01	-0.07	0.05
Digital Concepts	†	†	0.09	0.04	0.15	0.26
Self-Efficacy						
Self-Efficacy	0.07	-0.15	-0.15	0.23	0.21	0.09

† Not applicable.
* Difference in regression estimates between PBA and DBA is statistically significant, p <.05.

In summary, for research question 4, we did not observe, as hypothesized, that associations between the digital technology access, familiarity, and self-efficacy indices are more positive for the DBA sample than the PBA sample. In most cases, differences were not statistically significant and, when we did observe significant differences, they were in the opposite direction from what was hypothesized.

Research question 5. Do the observed relationships between indices and NAEP performance change when controlling for SES and other student characteristics?

The intent of research question 5 was to investigate whether results and conclusions from research question 4 changed when the analysis accounted for SES and other potentially confounding factors. More specially, we repeated the analyses for research question 4 but added to the regression model covariates for sex, race, school locale, NSLP eligibility, student with disability status, and ELL status.

An examination of Table 8 shows that the general pattern seen in Table 7 above is repeated here except that the two significant differences (DBA – PBA) reported for research question 4 were reduced in size, and neither remained statistically significant when analysis accounted for the additional student characteristics.

Table 8. Difference in Regression Estimates of the Relationship Between the Access at School Index and NAEP Achievement Across Modes (DBA – PBA) Using a Model That Accounts for Differences in Student Characteristics

	Grade 4		Grade 8		Grade 12	
Subject	**Math**	**Reading**	**Math**	**Reading**	**Math**	**Reading**
Access						
Home Access	-0.04	-0.02	0.08	0.11	0.11	0.19
School Access	-0.18	-0.18	-0.14	0.08	0.15	0.01
Familiarity						
Instruction	-0.06	0.25	0.30	0.14	0.16	0.12
Computer Use	-0.17	0.02	0.03	-0.15	0.07	-0.06
Tablet Use	-0.32	-0.11	0.05	-0.12	0.13	0.13
Digital Concepts	†	†	-0.21	0.12	0.04	0.12
Self-Efficacy						
Self-Efficacy	0.04	-0.11	-0.16	0.25	0.09	-0.12

† Not applicable.
* Difference in regression estimates between PBA and DBA is statistically significant, p <.05.

In summary, for research question 5, we did not observe any significant differences between the DBA and PBA samples in the estimated associations between the indices and NAEP achievement when controlling for potentially important sociodemographic characteristics of students.

Summary, Discussion, and Conclusion

The purpose of this study was to investigate the feasibility and utility of creating new measures of student digital technology access, familiarity, and self-efficacy. The motivation for this research was concern about the shift in the mode of NAEP administration from a PBA to a DBA, and any impacts that student access to and familiarity with digital technology might have on the validity of the assessment. Especially important in this regard was the impact on traditionally disadvantaged populations that may have differential exposure to digital technology.

Summary

Our first research question dealt with whether we could build reliable measures. We began our work by hypothesizing the importance of two major domains—access and familiarity. Research done by American Institutes for Research (AIR), using data from the pilot 2013 NAEP Technology and Engineering Literacy (TEL) study, found that digital self-efficacy was a potent predictor of NAEP TEL and, for this reason, digital self-efficacy became the third domain to examine. Searches were done for items that fell into these three domains, but ultimately the vast majority of items were newly developed. Small samples of fourth and eighth graders were asked to do think-alouds (cognitive laboratories) to review problems with any of the items. Changes were made based on this work as well as feedback from experts in the field. Both exploratory and confirmatory factor analyses were conducted to explore the dimensionality of the three domains. Based on the results of the factor analyses, we built indices that captured two subdomains of access—representing home and school access—and four subdomains of familiarity—familiarity based on computer use, tablet use, classroom instruction, and knowledge of digital concepts. Except for measures of home and school access to digital technology, we were able to build new measures of access and familiarity and digital self-efficacy that had acceptable to very good estimates of internal consistency.

The second research question examined whether there were subgroup differences in the measures created. We did not expect to find any based on gender, but thought that traditionally underserved populations (Blacks, Hispanics, NSLP-eligible students, ELLs, and students with disabilities) might indicate lower access to and familiarity with digital technology than those who are not underserved or otherwise disadvantaged. No differences were observed for gender. Somewhat surprisingly, we found no evidence that Black and Hispanic students were disadvantaged because of a lack of access to digital technology either at home or at school. Most surprising was the finding that disadvantaged students were much more likely to indicate familiarity with digital technology through the use of tablets and, to a lesser extent, computers than their more advantaged counterparts—just the opposite from that which was hypothesized. We did find, as hypothesized, that disadvantaged subpopulations generally reported lower digital self-efficacy and less familiarity with digital concepts than nondisadvantaged students.

Our third research question examined the relationship between access, familiarity, and self-efficacy, and performance on NAEP.[11] Our hypothesis was that relationships between the access, familiarity, and digital self-efficacy indices and NAEP scores would be positive. Although the familiarity with digital concepts and self-efficacy indices related to NAEP performance as hypothesized (and strongly so), access at school, familiarity through computer use, and familiarity through tablet use were all significantly *negatively* related to NAEP performance—an unexpected result that will be addressed in the Discussion section below.

The fourth research question focused on differential validity of the indices in predicting NAEP performance across the two modes of administration—DBA and PBA. The guiding hypothesis was that access and familiarity might well affect performance on the DBA—which by definition requires digital knowledge and skills—but the same was not true for performance on the paper version of NAEP (PBA). What we found was another surprise. In most cases, differences in regression coefficients were not statistically significant. Where we did find differences, they were in the opposite direction from what was hypothesized. That is, we found no evidence that computer access or familiarity were more important for taking the DBA than they were for taking the PBA.

The final research question re-estimated the results from the fourth research question but added control variables for major sociodemographic characteristics of students. The results, when controlling for the sociodemographic characteristics of students, did not significantly change the conclusions drawn for research question 4.

[11] The familiarity with digital concepts index was corrected for overclaiming (Kyllonen & Bertling, 2013).

Discussion

We were able to construct measures that with two exceptions—access to digital technology at home and access to digital technology at school—meet the 0.70 criterion for internal consistency reliability. Going forward, there are three ways to deal with these two measures given that they were not found to be reliable: (1) continue to use them as used here, but with cautions in using them clearly stated; (2) add items related to those two subdomains to future survey questionnaires; or (3) abandon the use of an index and instead focus on the individual items that make up the index.

To explore the third option, we studied the item-level correlations of access items with mathematics and reading performance for both the DBA and PBA samples and did not find evidence that this approach would change results. First, we found that the range of item-level correlations for the DBA and PBA samples for both subject areas and grade levels were very similar as were the end points of the range. That is, there was no evidence that the correlations at the item level were, on average, larger in the DBA than in the PBA sample. Second, there were only two items where the zero-order correlations in the DBA sample were larger than in the PBA sample, having a computer at home and having Wi-Fi at home, and only for Grade 12 reading achievement. Of these two items, only having Wi-Fi at home had a statistically significantly larger correlation with reading achievement in the DBA sample compared with the PBA sample.[12]

We also wondered whether the within-school variation was so substantial so as to limit the overall amount of variation in the access indices, thereby reducing the size of the reliabilities associated with the access indices. To examine this question, we computed intraclass correlations (ICCs) for both the home and school access indices. They were 0.20, 0.27, and 0.31 for Grades 4, 8, and 12, respectively, for the school access measure compared with 0.05, 0.04, and 0.04, respectively, for home access. Clearly, the ICCs for school access are larger than those for home access (as might be expected) but they appear not to have substantially attenuated the sizes of the reliabilities of the school access indices compared with those of the home access indices. Although two of the values were marginally larger for the home access indices than for the school access measures (see Tables 4, 5, and 6), the home access index had one more item than the school access index. So, within-school variation does not appear to account for the low reliabilities of the access indices.

Finally, we examined whether there might have been substantial variation in the home and school access reliabilities by major subgroups (gender, race/identity, NSLP, ELL, and student with disability status). Although there was some variation (e.g., male, Black, and ELL students all had slightly lower reliabilities for both home and school access), it was not substantial enough to explain the overall low reliabilities of home and school access.

[12] The two values were r= 0.24 in the DBA sample versus r=0.11 in the PBA sample. The parallel values for having a computer at home and Grade 12 reading achievement were r=0.20 and r=0.12, respectively, which was in the predicted direction but not statistically significant.

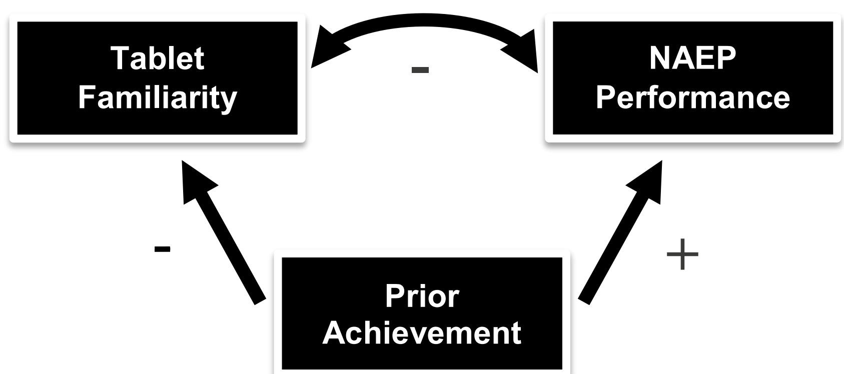
Given this set of results, our recommendation is to add new items. As is well known, reliability is a function of the number of items in addition to the correlation among items; hence, adding items should improve reliability (Bohrnstedt, 2010). The additional items could be measures of new technologies. As new technologies develop, it will be important that our measures of access include them. Also, even without changes in technology, there are ways in which items could be added to improve access measures, both at home and at school. As the Rideout and Katz (2016) study found, many lower SES families are using old technology, have slow Internet connectivity, and/or face regular service cutoffs because they cannot afford to pay their bill. They also may share a single device or rely only on a mobile device for getting on the Internet. Similar issues may beset schools. All of these are facets of access that could be used to enrich and improve both the reliability and the current measures of home and school access. It is important not to forget that access may be a necessary condition for academic performance in a technological age, but, as our results indicate, not sufficient—a point to which we will return below. We found only very weak, statistically insignificant relationships between home access and NAEP performance. Also, for school access, the relationships that were significant were in the wrong direction. Of course, it could be argued that this suggests an issue of validity that should be corrected by adding items of the sort mentioned above.

Our four measures of technology familiarity all had acceptable to very good estimates of internal consistency reliability. However, in examining their relationships with NAEP performance, we saw that either the relationships were not statistically significant or, if they were, they were not in the hypothesized direction. The sole exception was our measure of familiarity with digital concepts, which was substantially correlated with NAEP performance, especially when corrected for overclaiming. These results suggest an obvious question: Why did we find that having familiarity with computers and tablets was negatively related to performance, especially for familiarity with tablets, which had the largest negative correlations?

Although we cannot investigate this question further with our current dataset, one possibility is that digital technology (especially tablets) is being used in some schools more often with lower performing students (perhaps as a substitute for other opportunities to learn). If so, giving a child a tablet could be associated with low prior achievement. One hypothesis we had was that schools with many underperforming students used some or much of their Title I money to buy laptop computers and, more likely, less expensive tablets. Another related possibility is that when teachers give students who are struggling tablets to use without a strong curricular rationale for doing so, this activity is replacing what could have been more quality instruction provided by the teacher. Exercises abound on the Internet that can be easily loaded onto tablets (and laptops) for use with students who are having problems learning materials; some of them are not much better than the old "drill-and-kill" paper-and-pencil exercises. Either way, if it is the case that laptops, and especially tablets, are being used more often with lower performing students, prior achievement would be an omitted variable in our analysis that could lead to a negative relationship between an index such as tablet familiarity and NAEP performance. We have illustrated this possibility in Figure 11 below.

In Figure 11, we have shown a positive relationship between prior achievement (the unmeasured, omitted variable) and NAEP performance (NAEP as a measure of academic achievement), and a negative relationship between prior achievement and tablet familiarity (low-performing students are given greater access to tablets). If these two relationships are modelled correctly (and we suspect they are), these are sufficient for understanding the negative relationship between tablet use and NAEP performance. That is, the relationship between tablet use and NAEP performance is not a causal one, but instead is spurious, due to a common cause—prior performance. This is speculative, of course, but strikes us as a plausible explanation that perhaps could be examined through either the NAEP school or teacher contextual questionnaires. Unfortunately, our dataset did not have links to these questionnaires, but they could be added. It also is worth noting that school access, familiarity though computer use, and familiarity through tablet use have sizeable relationships among them, so it is plausible that there is a common omitted variable confounding the relationship that we observed.

Figure 11. Possible Omitted Variable Bias in Estimating the Relationship Between Tablet Familiarity and NAEP Performance



There is one other datum about tablet use that bears mentioning. Recall in the literature review the finding from the TRU study that Black and Hispanic students reported doing more homework on smartphones and tablets than White students (Sarmiento & Glauber, 2012). We did not ask for this information in our survey, but we did ask about their access to devices in the schools and analyzed the data by race/ethnicity. If Black and Hispanic students are disproportionately being asked to do work on tablets as a substitute for other opportunities to learn, then we would expect them to report having more access to their own tablets at school than White students do. That is exactly what we found at Grades 4 and 8. Although the differences are not huge, they are in the predicted direction. At Grade 4, 19 percent of Blacks and 18 percent of Hispanics reported having their own access to tablets at school compared with 14 percent of White students. The same pattern is found at Grade 8, although the percentages are smaller: 10 percent of Blacks and 9 percent of Hispanics reported having their own access to tablets at school compared with 8 percent of Whites.[13]

[13] We also checked to see whether nonlinearity (e.g., ceiling effects) could explain the unexpected findings reported above. To do so, we plotted means for mathematics and reading performance (separately) conditional on the various outcomes on the Grade 12 home access, school access, and

The index for measuring familiarity with digital concepts, both in terms of its reliabilities at Grades 8 and 12 (it was not measured at Grade 4) and its relationship to NAEP performance in the DBA sample, was substantial. It was more highly related to NAEP performance than any of the other indices. However, it predicted performance on NAEP in the PBA sample as well as it did in the DBA sample. That is, the measure failed to show differential validity by correlating with performance in the DBA sample but not the PBA sample.

The narrative for the digital self-efficacy measures is similar. The measure of this construct has high internal consistency and correlates with NAEP performance in the DBA sample. However, the measure predicts performance as well in the PBA sample as it does in the DBA sample.

Conclusion

The evidence from this study is quite incontrovertible: We were able to create measures of familiarity with digital technology and digital concepts with high reliabilities. We did less well with creating measures of home and school access. However, we were unable to demonstrate that any of the measures were differentially valid in the sense of predicting NAEP performance in the DBA but not the PBA samples. Ultimately, our study did not find any evidence that would lead us be concerned about the transition of NAEP to a DBA.

One of our hopes had been to create a set of reliable and valid measures that could be used by NAEP through at least the next several testing cycles. The study is being replicated as part of the 2017 NAEP assessment. Unfortunately, the results from the 2015 study were not known far enough in advance to be able to include additional questions to try to improve the measurement of school and home access. Nonetheless, it will be important to learn whether the results from the current year's study are replicated or not.

In addition, changes in NAEP and in society in the use of technology could lead to different results. First, we know that there are changes to NAEP item types. The 2015 DBA assessment included only items that had been developed for the PBA and then adapted, as needed, for the digital platform. In contrast, the 2017 assessment includes some items developed specifically for the digital platform. Also, as NAEP is likely to move toward including even more challenging items in current development, such as the scenario-based assessments that require students to interact with the task, access to and familiarity with digital technology may be even more important. Second, technology changes and disseminates rapidly; thus, student access and familiarity in 2017 might be different than that in 2015. Both trends could potentially lead to different findings.

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tablet familiarity indices, respectively. We also repeated these analyses using the Grade 4 and 8 home access indices. None of the analyses provided any evidence that nonlinearity could explain the unexpected null and negative relationships observed.

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Appendix A. Data

The numbers of students to whom the study questionnaire was administered by grade, subject, and mode are provided in Table A1.

Table A1. Sample Size for Each Grade by Mode and Subject

	Grade 4		Grade 8		Grade 12	
Subject	**PBA**	**DBA**	**PBA**	**DBA**	**PBA**	**DBA**
Math	1,100	600	1,300	500	1,100	500
Reading	1,100	600	1,400	800	1,600	700
Science	1,000	900	1,300	900	900	800
Total by mode	**3,100**	**2,100**	**4,000**	**2,200**	**3,600**	**2,000**
Total	**5,200**		**6,200**		**5,600**	

NOTE. The sample sizes here do not include about 100 students removed from the Grade 4 PBA sample and approximately 100 students removed from the Grade 8 PBA sample. At Grade 4, 50 students were removed because their assessment subject could not be identified and about 60 students were removed because they were administered the Knowledge and Skills Acquisition (KASA) assessment. All of the Grade 8 students removed had been administered the KASA assessment. Numbers are rounded to nearest 10 or 100. PBA=paper-based assessment; DBA=digitally based assessment.

Appendix B. Student Questionnaires for This Study

Grade 4 Questionnaire

SECTION 5

Section 5

This section has 46 questions. Mark your answers in your booklet. Fill in only **one** oval for each question.

VH155319

1. How much do you know about using computers and other digital devices?

   Ⓐ I hardly know anything at all.
   Ⓑ I know something.
   Ⓒ I know quite a bit.
   Ⓓ I know a lot.

VH166527

2. **At home**, do you have a **laptop or desktop computer** that is only for your use?

   Ⓐ Yes
   Ⓑ No

VH166529

3. **At home**, is there a **laptop or desktop computer** that is shared between you and others?

   Ⓐ Yes
   Ⓑ No

VH166524

4. **At home**, do you have a **tablet** that is only for your use?

   Ⓐ Yes
   Ⓑ No

VH166526

5. **At home**, is there a **tablet** that is shared between you and others?

   Ⓐ Yes
   Ⓑ No

VH166530

6. **At home**, do you have **Wi-Fi** or some other **Internet connection** you can use?

   Ⓐ Yes
   Ⓑ No

VH166531

7. **At home**, do you have a **smartphone** that is only for your use?

   Ⓐ Yes
   Ⓑ No

VH156034

8. When did you first use a **laptop or desktop computer**?

   Ⓐ I have never used one.
   Ⓑ Before I was in kindergarten
   Ⓒ When I was in kindergarten
   Ⓓ When I was in first, second, or third grade
   Ⓔ When I was in fourth grade

LINVXB1 Page 1 **GO ON TO THE NEXT PAGE**

Section 5

VH156037

9. When did you first use a **tablet**?

   Ⓐ I have never used one.
   Ⓑ Before I was in kindergarten
   Ⓒ When I was in kindergarten
   Ⓓ When I was in first, second, or third grade
   Ⓔ When I was in fourth grade

VH156042

10. When did you first use a **smartphone**?

   Ⓐ I have never used one.
   Ⓑ Before I was in kindergarten
   Ⓒ When I was in kindergarten
   Ⓓ When I was in first, second, or third grade
   Ⓔ When I was in fourth grade

VH156125

11. **On a weekday**, about **how many hours** do you use a **laptop or desktop computer** for doing schoolwork, including homework?

   Ⓐ None
   Ⓑ Less than an hour
   Ⓒ 1 to 2 hours
   Ⓓ 2 to 3 hours
   Ⓔ 3 to 4 hours
   Ⓕ More than 4 hours

VH156119

12. **On a weekday**, about **how many hours** do you use a **tablet** for doing schoolwork, including homework?

   Ⓐ None
   Ⓑ Less than an hour
   Ⓒ 1 to 2 hours
   Ⓓ 2 to 3 hours
   Ⓔ 3 to 4 hours
   Ⓕ More than 4 hours

VH176734

13. **At school**, were you taught how to type on a computer keyboard using the correct fingers?

   Ⓐ Yes
   Ⓑ No

VH176739

14. **At school**, were you taught how to write sentences and paragraphs using a computer?

   Ⓐ Yes
   Ⓑ No

VH176741

15. **At school**, were you taught how to edit text using a computer?

   Ⓐ Yes
   Ⓑ No

LINVXB1 Page 2 **GO ON TO THE NEXT PAGE**

Grade 4 Questionnaire Continued

VH176742

16. **At school**, were you taught how to search for information on the Internet?

- Ⓐ Yes
- Ⓑ No

VH176745

17. **At school**, were you taught how to use a tablet?

- Ⓐ Yes
- Ⓑ No

VH176748

18. **At school**, were you taught how to draw a picture using a computer?

- Ⓐ Yes
- Ⓑ No

VH176750

19. **At school**, were you taught how to look up the meaning of a word using a computer?

- Ⓐ Yes
- Ⓑ No

VH176753

20. **At school**, are there **laptop or desktop computers** that you can use for schoolwork?

- Ⓐ Yes
- Ⓑ No

VH176759

21. **At school**, are there **tablets** that you can use for schoolwork?

- Ⓐ Yes
- Ⓑ No

VH182302

22. **At school**, is there **Wi-Fi** or some other **Internet connection** you can use for schoolwork?

- Ⓐ Yes
- Ⓑ No

VH176772

23. Does your teacher use a computer when teaching your class?

- Ⓐ Yes
- Ⓑ No

VH176773

24. Does your teacher require you to use computers in the classroom?

- Ⓐ Yes
- Ⓑ No

VH196393

25. Has your school assigned you a **laptop or desktop computer** that only you can use?

- Ⓐ No
- Ⓑ Yes, but I cannot take it home with me.
- Ⓒ Yes, and I can take it home with me (laptop only).

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VH196403

26. Has your school assigned you a **tablet** that only you can use?

- Ⓐ No
- Ⓑ Yes, but I cannot take it home with me.
- Ⓒ Yes, and I can take it home with me.

VH156075

27. **This school year**, how often have you used a **laptop or desktop computer** to write a short paper (less than a page) for school?

- Ⓐ Never
- Ⓑ A few times
- Ⓒ Once every few weeks
- Ⓓ About once a week
- Ⓔ More than once a week

VH156078

28. **This school year**, how often have you used a **laptop or desktop computer** to write a paper for school that was longer than a page?

- Ⓐ Never
- Ⓑ A few times
- Ⓒ Once every few weeks
- Ⓓ About once a week
- Ⓔ More than once a week

VH156081

29. **This school year**, how often have you used a **laptop or desktop computer** to search the Internet for a school project?

- Ⓐ Never
- Ⓑ A few times
- Ⓒ Once every few weeks
- Ⓓ About once a week
- Ⓔ More than once a week

VH156082

30. **This school year**, how often have you used a **laptop or desktop computer** to practice things in **mathematics** that you were having trouble learning?

- Ⓐ Never
- Ⓑ A few times
- Ⓒ Once every few weeks
- Ⓓ About once a week
- Ⓔ More than once a week

VH176775

31. **This school year**, how often have you used a **laptop or desktop computer** to practice things in **reading** that you were having trouble learning?

- Ⓐ Never
- Ⓑ A few times
- Ⓒ Once every few weeks
- Ⓓ About once a week
- Ⓔ More than once a week

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Grade 4 Questionnaire Continued

VH177580

32. **This school year**, how often have you used a **laptop or desktop computer** to take a test?
    - Ⓐ Never
    - Ⓑ A few times
    - Ⓒ Once every few weeks
    - Ⓓ About once a week
    - Ⓔ More than once a week

VH156083

33. **This school year**, how often have you used a **tablet** to write a short paper (less than a page) for school?
    - Ⓐ Never
    - Ⓑ A few times
    - Ⓒ Once every few weeks
    - Ⓓ About once a week
    - Ⓔ More than once a week

VH156086

34. **This school year**, how often have you used a **tablet** to write a paper for school that was longer than a page?
    - Ⓐ Never
    - Ⓑ A few times
    - Ⓒ Once every few weeks
    - Ⓓ About once a week
    - Ⓔ More than once a week

VH156087

35. **This school year**, how often have you used a **tablet** to search the Internet for a school project?
    - Ⓐ Never
    - Ⓑ A few times
    - Ⓒ Once every few weeks
    - Ⓓ About once a week
    - Ⓔ More than once a week

VH156092

36. **This school year**, how often have you used a **tablet** to practice things in **mathematics** that you were having trouble learning?
    - Ⓐ Never
    - Ⓑ A few times
    - Ⓒ Once every few weeks
    - Ⓓ About once a week
    - Ⓔ More than once a week

VH176785

37. **This school year**, how often have you used a **tablet** to practice things in **reading** that you were having trouble learning?
    - Ⓐ Never
    - Ⓑ A few times
    - Ⓒ Once every few weeks
    - Ⓓ About once a week
    - Ⓔ More than once a week

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VH177588

38. **This school year**, how often have you used a **tablet** to take a test?
    - Ⓐ Never
    - Ⓑ A few times
    - Ⓒ Once every few weeks
    - Ⓓ About once a week
    - Ⓔ More than once a week

VH155541

39. Which best describes the way you type on a computer keyboard?
    - Ⓐ I don't know how to type using a computer keyboard.
    - Ⓑ I can type with one or two fingers, but I have to search for where the letter keys are.
    - Ⓒ I can type with one or two fingers, and I know where most of the letter keys are.
    - Ⓓ I can type with all ten fingers when I look at the keyboard.
    - Ⓔ I can type with all ten fingers without looking at the keyboard.

VH156071

40. Compared to other students in your class, how fast do you type on a computer keyboard?
    - Ⓐ I am slower than most students.
    - Ⓑ I type about the same speed as others.
    - Ⓒ I am faster than most students.
    - Ⓓ I don't know.

VH176951

41. Would you rather take a test at school using paper and pencil or using a computer?
    - Ⓐ Paper and pencil
    - Ⓑ Computer

VH176789

42. Do you think you would be able to write sentences and paragraphs using a computer?
    - Ⓐ I definitely can't.
    - Ⓑ I probably can't.
    - Ⓒ I probably can.
    - Ⓓ I definitely can.

VH176787

43. Do you think you would be able to edit text using a computer?
    - Ⓐ I definitely can't.
    - Ⓑ I probably can't.
    - Ⓒ I probably can.
    - Ⓓ I definitely can.

VH176790

44. Do you think you would be able to use a touchscreen on a computer, tablet, or smartphone?
    - Ⓐ I definitely can't.
    - Ⓑ I probably can't.
    - Ⓒ I probably can.
    - Ⓓ I definitely can.

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Grade 4 Questionnaire Continued

VH176792

45. Do you think you would be able to look up the meaning of a word using a computer?

    Ⓐ I definitely can't.

    Ⓑ I probably can't.

    Ⓒ I probably can.

    Ⓓ I definitely can.

VH176793

46. Do you think you would be able to draw a picture using a computer?

    Ⓐ I definitely can't.

    Ⓑ I probably can't.

    Ⓒ I probably can.

    Ⓓ I definitely can.

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Grade 8 Questionnaire

Note: The Grade 12 questionnaire is not included in the appendix because it is the same as the Grade 8 questionnaire.

SECTION 5

Section 5

This section has 23 questions. Mark your answers in your booklet. Fill in only **one** oval for each question.

VH155319

1. How much do you know about using computers and other digital devices?

Ⓐ I hardly know anything at all.

Ⓑ I know something.

Ⓒ I know quite a bit.

Ⓓ I know a lot.

VH155275

2. **At home**, do you have any of the following? Fill in **one** oval on each line.

	Yes	No	
a. A **laptop or desktop computer** that is only for your use	Ⓐ	Ⓑ	VH155283
b. A **laptop or desktop computer** that is shared between you and others	Ⓐ	Ⓑ	VH155284
c. A **tablet** that is only for your use	Ⓐ	Ⓑ	VH155280
d. A **tablet** that is shared between you and others	Ⓐ	Ⓑ	VH155281
e. **Wi-Fi** or some other **Internet connection** you can use	Ⓐ	Ⓑ	VH155285
f. A **smartphone** that is only for your use	Ⓐ	Ⓑ	VH155287

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Section 5

VH155872

3. When did you first use a **laptop or desktop computer**?

Ⓐ I have never used one.

Ⓑ Before I was in kindergarten

Ⓒ When I was in kindergarten

Ⓓ When I was in first, second, or third grade

Ⓔ When I was in fourth or fifth grade

Ⓕ When I was in sixth, seventh, or eighth grade

VH155875

4. When did you first use a **tablet**?

Ⓐ I have never used one.

Ⓑ Before I was in kindergarten

Ⓒ When I was in kindergarten

Ⓓ When I was in first, second, or third grade

Ⓔ When I was in fourth or fifth grade

Ⓕ When I was in sixth, seventh, or eighth grade

VH155882

5. When did you first use a **smartphone**?

Ⓐ I have never used one.

Ⓑ Before I was in kindergarten

Ⓒ When I was in kindergarten

Ⓓ When I was in first, second, or third grade

Ⓔ When I was in fourth or fifth grade

Ⓕ When I was in sixth, seventh, or eighth grade

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Grade 8 Questionnaire Continued

VH155330

6. **On a weekday**, about **how many hours** do you use a **laptop or desktop computer** for doing schoolwork, including homework?

   Ⓐ None
   Ⓑ Less than an hour
   Ⓒ 1 to 2 hours
   Ⓓ 2 to 3 hours
   Ⓔ 3 to 4 hours
   Ⓕ More than 4 hours

VH155332

7. **On a weekday**, about **how many hours** do you use a **tablet** for doing schoolwork, including homework?

   Ⓐ None
   Ⓑ Less than an hour
   Ⓒ 1 to 2 hours
   Ⓓ 2 to 3 hours
   Ⓔ 3 to 4 hours
   Ⓕ More than 4 hours

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VH155373

8. Were you taught any of the following **at school**? Fill in **one** oval on each line.

	Yes	No	
a. How to type on a computer keyboard using the correct fingers	Ⓐ	Ⓑ	VH155375
b. How to write sentences and paragraphs using a computer	Ⓐ	Ⓑ	VH155376
c. How to edit text using a computer	Ⓐ	Ⓑ	VH176918
d. How to search for information on the Internet	Ⓐ	Ⓑ	VH155377
e. How to use a tablet	Ⓐ	Ⓑ	VH155378
f. How to draw a picture using a computer	Ⓐ	Ⓑ	VH155379
g. How to look up the meaning of a word using a computer	Ⓐ	Ⓑ	VH155380
h. How to create a spreadsheet using a computer	Ⓐ	Ⓑ	VH155381
i. How to create a presentation using a computer	Ⓐ	Ⓑ	VH155382
j. How to run simulations using a computer	Ⓐ	Ⓑ	VH155384
k. How to write a computer program or app	Ⓐ	Ⓑ	VH155385
l. How to create a graph or chart using a computer	Ⓐ	Ⓑ	VH155386
m. How to maintain a website or blog	Ⓐ	Ⓑ	VH155387
n. How to install new software or apps	Ⓐ	Ⓑ	VH155388
o. How to troubleshoot problems with a computer	Ⓐ	Ⓑ	VH155383

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Grade 8 Questionnaire Continued

VH155477

9. Which of the following are true about the ways in which you and your teachers use computers **at school**? Fill in **one** oval on each line.

	Yes	No	
a. In most of my classes there are **laptop or desktop computers** that I can use for schoolwork.	Ⓐ	Ⓑ	VH155479
b. In most of my classes there are **tablets** that I can use for schoolwork.	Ⓐ	Ⓑ	VH155482
c. There is **Wi-Fi** or some other **Internet connection** that I can use for schoolwork.	Ⓐ	Ⓑ	VH182383
d. Most of my teachers use computers when teaching my classes.	Ⓐ	Ⓑ	VH155484
e. Most of my teachers require us to use computers in the classroom.	Ⓐ	Ⓑ	VH155485

VH196393

10. Has your school assigned you a **laptop or desktop computer** that only you can use?

Ⓐ No

Ⓑ Yes, but I cannot take it home with me.

Ⓒ Yes, and I can take it home with me (laptop only).

VH196403

11. Has your school assigned you a **tablet** that only you can use?

Ⓐ No

Ⓑ Yes, but I cannot take it home with me.

Ⓒ Yes, and I can take it home with me.

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VH155495

12. **This school year**, how often have you used a **laptop or desktop computer** to do each of the following? Fill in **one** oval on each line.

	Never	A few times	Once every few weeks	About once a week	More than once a week	
a. Write a short paper (less than a page) for school	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH155496
b. Write a paper for school that was longer than a page	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH155497
c. Search the Internet for a school project	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH155498
d. Practice things in **mathematics** that you were having trouble learning	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH176943
e. Practice things in **reading** that you were having trouble learning	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH176945
f. Take a test	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH176946
g. Create a map	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH224684
h. Work on a website or blog that you maintain	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH224685
i. Create a multimedia presentation *on your own*	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH224686
j. Work collaboratively *with a team of students* to create a multimedia presentation	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH224690

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Grade 8 Questionnaire Continued

VH155524

13. **This school year**, how often have you used a **tablet** to do each of the following? Fill in **one** oval on each line.

	Never	A few times	Once every few weeks	About once a week	More than once a week	
a. Write a short paper (less than a page) for school	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH155525
b. Write a paper for school that was longer than a page	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH155528
c. Search the Internet for a school project	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH155527
d. Practice things in **mathematics** that you were having trouble learning	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH176938
e. Practice things in **reading** that you were having trouble learning	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH176925
f. Take a test	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH176927
g. Create a map	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH224714
h. Work on a website or blog that you maintain	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH224720
i. Create a multimedia presentation *on your own*	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH224722
j. Work collaboratively *with a team of students* to create a multimedia presentation	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	VH224725

VH155541

14. Which best describes the way you type on a computer keyboard?

Ⓐ I don't know how to type using a computer keyboard.

Ⓑ I can type with one or two fingers, but I have to search for where the letter keys are.

Ⓒ I can type with one or two fingers, and I know where most of the letter keys are.

Ⓓ I can type with all ten fingers when I look at the keyboard.

Ⓔ I can type with all ten fingers without looking at the keyboard.

VH155884

15. Compared to other students in your English/language arts class, how fast do you type on a computer keyboard?

Ⓐ I am slower than most students.

Ⓑ I type about the same speed as others.

Ⓒ I am faster than most students.

Ⓓ I don't know.

VH176951

16. Would you rather take a test at school using paper and pencil or using a computer?

Ⓐ Paper and pencil

Ⓑ Computer

Grade 8 Questionnaire Continued

VH155799

17. Do you think you would be able to do each of the following? Fill in **one** oval on each line.

	I definitely can't.	I probably can't.	I probably can.	I definitely can.	
a. Write sentences and paragraphs using a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH176967
b. Edit text using a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155803
c. Use a touchscreen on a computer, tablet, or smartphone	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH176970
d. Look up the meaning of a word using a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155810
e. Draw a picture using a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155811
f. View or download digital media	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155800
g. Create a presentation using a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155820
h. Create a spreadsheet using a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155802
i. Install new software or apps	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155804
j. Participate in online discussions, forums, social networking sites, or virtual communities	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155805
k. Maintain a website or blog	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155806
l. Search for information on the Internet	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155807
m. Run simulations using a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155808
n. Create a graph or chart using a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155809
o. Write a computer program or app	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155812
p. Troubleshoot a problem with a computer	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH196843
q. Figure out how to use new functions of a digital device that I am not yet familiar with	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH224738

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VH155876

18. On a scale from 0 to 10, where 0 is not at all familiar and 10 is very familiar, **how familiar with using computers and other digital devices are <u>you</u>?**

Ⓐ 0
Ⓑ 1
Ⓒ 2
Ⓓ 3
Ⓔ 4
Ⓕ 5
Ⓖ 6
Ⓗ 7
Ⓘ 8
Ⓙ 9
Ⓚ 10

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Grade 8 Questionnaire Continued

VH155957

Please read the descriptions of the following four eighth-grade students. After you read each description, you will be asked to answer a question about each student based on the information provided.

VH155958

19. **Linda** often uses apps to talk to her friends or to play games. She does some of her homework on her laptop and knows how to write and create tables using a computer. Linda cannot type with 10 fingers but is pretty fast with two fingers and mostly finds the right keys.

    On a scale from 0 to 10, where 0 is not at all familiar and 10 is very familiar, **how familiar with using computers and other digital devices do you think Linda is?**

    Ⓐ 0
    Ⓑ 1
    Ⓒ 2
    Ⓓ 3
    Ⓔ 4
    Ⓕ 5
    Ⓖ 6
    Ⓗ 7
    Ⓘ 8
    Ⓙ 9
    Ⓚ 10

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VH155961

20. **Tom** often uses apps to talk to his friends or to play games. He does most of his homework on a computer and knows how to write and edit papers on a computer and how to create complex tables or charts. He also created a few presentations using a computer. Tom can type pretty accurately using ten fingers when looking at the computer keyboard.

    On a scale from 0 to 10, where 0 is not at all familiar and 10 is very familiar, **how familiar with using computers and other digital devices do you think Tom is?**

    Ⓐ 0
    Ⓑ 1
    Ⓒ 2
    Ⓓ 3
    Ⓔ 4
    Ⓕ 5
    Ⓖ 6
    Ⓗ 7
    Ⓘ 8
    Ⓙ 9
    Ⓚ 10

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Grade 8 Questionnaire Continued

VH155960

21. **Susan** often uses apps on a smartphone or tablet and does most of her homework on a laptop. She is good at writing and editing papers on her computer and has experience with creating complex tables and charts. Susan can type fast and accurately with 10 fingers without looking at the computer keyboard. She also knows a couple of programming languages. This school year, she built her first app.

On a scale from 0 to 10, where 0 is not at all familiar and 10 is very familiar, **how familiar with using computers and other digital devices do you think Susan is?**

- Ⓐ 0
- Ⓑ 1
- Ⓒ 2
- Ⓓ 3
- Ⓔ 4
- Ⓕ 5
- Ⓖ 6
- Ⓗ 7
- Ⓘ 8
- Ⓙ 9
- Ⓚ 10

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VH155959

22. **Kevin** sometimes plays games on his smartphone or a computer, but he usually does not use a computer for his homework. He used a computer a couple of times to write a paper but never used a computer to create tables, charts, or presentations. Kevin can type with one or two fingers but has to search to find the correct keys on the computer keyboard.

On a scale from 0 to 10, where 0 is not at all familiar and 10 is very familiar, **how familiar with using computers and other digital devices do you think Kevin is?**

- Ⓐ 0
- Ⓑ 1
- Ⓒ 2
- Ⓓ 3
- Ⓔ 4
- Ⓕ 5
- Ⓖ 6
- Ⓗ 7
- Ⓘ 8
- Ⓙ 9
- Ⓚ 10

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Grade 8 Questionnaire Continued

VH155750

23. How familiar are you with each of the following? Fill in **one** oval on each line.

	Never heard of it	**Heard of it once or twice**	**Heard of it often**	**Know it well, understand the concept**	
a. E-reader	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155751
b. Wi-Fi	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155752
c. Firewall	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155753
d. Hyperlink	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155756
e. Neuro-digital computing	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155757
f. Instant messaging	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155758
g. CPU	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155759
h. Track changes	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155760
i. Cut and paste	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155761
j. Pyramidal browser	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155762
k. Pivot table	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155763
l. Spreadsheet	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155765
m. Limbic wire	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155766
n. Spinalbyte	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155767
o. Cloud computing	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155768
p. Server	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155769
q. Root directory	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155770
r. Compiler	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155771
s. ASCII	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155772
t. Callosum board	Ⓐ	Ⓑ	Ⓒ	Ⓓ	VH155779

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Appendix C. Access Item Percentages

The following tables report the percentages of students with different types of home and school access to digital technology overall and by subpopulations.

Table C1. Access to Digital Technology at Home by Selected Student and School Characteristics: Grade 4

Student or School Characteristic	N	Wi-Fi or Internet		Smart-phone		Computer or Laptop: Both Own and Shared		Computer or Laptop: Own but Not Shared		Computer or Laptop: Shared but Not Own		Computer or Laptop: No Access		Tablet: Both Own and Shared		Tablet: Own but Not Shared		Tablet: Shared but Not Own		Tablet: No Access	
		%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Total	3,300	91	0.5	36	0.9	37	0.8	11	0.5	38	0.8	15	0.6	25	0.8	38	0.9	20	0.7	18	0.7
Sex																					
Male	1,700	91	0.7	37	1.2	37	1.2	12	0.8	35	1.2	17	0.9	25	1.1	35	1.2	21	1.0	18	1.0
Female	1,600	91	0.7	35	1.2	37	1.2	10	0.7	40	1.2	13	0.8	24	1.1	40	1.2	19	1.0	17	0.9
Race/ethnicity																					
White	1,400	94	0.6	32	1.2	33	1.2	9	0.7	48	1.3	11	0.8	22	1.1	39	1.3	22	1.1	17	1.0
Black	700	88	1.2	50	1.9	41	1.9	14	1.3	25	1.6	20	1.5	25	1.6	43	1.9	15	1.3	17	1.4
Hispanic	900	88	1.1	35	1.6	41	1.7	11	1.0	29	1.5	19	1.3	26	1.5	35	1.6	19	1.4	20	1.4
Asian	200	96	1.7	21	3.3	29	3.7	16	3	48	4.1	7	2.0	27	3.6	25	3.5	32	3.8	17	3.1
Other	100	93	2.6	34	4.7	41	4.8	13	3.2	38	4.7	9	2.7	31	4.5	33	4.6	19	3.9	17	3.6
ELL status																					
ELL	400	83	2.0	33	2.5	43	2.6	13	1.8	18	2.0	26	2.3	30	2.5	31	2.5	17	2.1	22	2.2
Non-ELL	2,900	92	0.5	37	0.9	36	0.9	11	0.6	40	0.9	14	0.6	24	0.8	39	0.9	20	0.7	17	0.7
Disability status																					
SD	400	85	1.9	38	2.6	40	2.6	11	1.7	28	2.4	21	2.1	28	2.4	32	2.5	19	2.1	21	2.1
Non-SD	2,900	92	0.5	36	0.9	37	0.9	11	0.6	39	0.9	14	0.6	24	0.8	38	0.9	20	0.8	17	0.7
NSLP status																					
Eligible	2,000	87	0.8	38	1.1	40	1.1	11	0.7	30	1.0	20	0.9	25	1.0	37	1.1	18	0.9	21	0.9
Not eligible	1,300	96	0.5	34	1.3	33	1.3	10	0.8	49	1.4	8	0.7	25	1.2	39	1.3	23	1.2	13	0.9
School locale																					
City	1,100	90	0.9	37	1.5	39	1.5	11	1.0	33	1.4	17	1.1	25	1.3	36	1.5	20	1.2	19	1.2
Suburb	1,300	94	0.7	37	1.4	36	1.4	11	0.9	42	1.4	12	0.9	25	1.2	38	1.4	22	1.2	16	1.0
Town	300	84	2.0	37	2.6	39	2.6	11	1.7	31	2.5	19	2.1	24	2.3	37	2.6	16	2.0	23	2.3
Rural	600	90	1.2	33	1.9	34	2.0	10	1.2	42	2.0	15	1.5	22	1.7	41	2.0	20	1.6	17	1.5

Notes provided after Table C6.

Table C2. Access to Digital Technology at School by Selected Student and School Characteristics: Grade 4

Student or School Characteristic	*N*	Wi-Fi or Internet		Computer or Laptop: Both Own and Shared		Computer or Laptop: Own but Not Shared		Computer or Laptop: Shared but Not Own		Computer or Laptop: No Access		Tablet: Both Own and Shared		Tablet: Own but Not Shared		Tablet: Shared but Not Own		Tablet: No Access	
		%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Total	3,300	80	0.7	21	0.7	5	0.4	56	0.9	17	0.7	12	0.6	4	0.3	31	0.8	53	0.9
Sex																			
Male	1,700	78	1.0	23	1.0	6	0.6	53	1.3	19	1.0	13	0.9	4	0.5	31	1.2	52	1.2
Female	1,600	82	1.0	20	1.0	5	0.6	59	1.2	16	0.9	11	0.8	4	0.5	31	1.1	55	1.2
Race/ethnicity																			
White	1,400	83	1.0	19	1.0	4	0.5	62	1.3	15	0.9	12	0.9	2	0.4	36	1.3	51	1.3
Black	700	76	1.6	29	1.7	8	1.1	48	1.9	16	1.4	12	1.2	7	1.0	28	1.7	52	1.9
Hispanic	900	79	1.4	21	1.4	6	0.9	53	1.7	20	1.4	13	1.1	5	0.7	25	1.5	57	1.7
Asian	200	78	3.4	14	2.8	4	1.6	59	4.0	23	3.4	9	2.4	5	1.7	30	3.8	56	4.1
Other	100	78	4.1	19	3.8	4	1.9	57	4.8	20	4.0	14	3.4	3	1.6	29	4.5	54	4.9
ELL status																			
ELL	400	80	2.3	24	2.3	9	1.6	47	2.7	19	2.1	17	2.0	6	1.4	29	2.5	47	2.7
Non-ELL	2,900	80	0.7	21	0.8	5	0.4	57	0.9	17	0.7	12	0.6	4	0.3	31	0.9	54	0.9
Disability status																			
SD	400	76	2.3	25	2.3	11	1.7	48	2.8	16	1.9	19	2.2	7	1.4	32	2.5	42	2.6
Non-SD	2,900	80	0.7	21	0.8	5	0.4	57	0.9	17	0.7	11	0.6	4	0.4	31	0.9	55	0.9
NSLP status																			
Eligible	2,000	77	1.0	21	0.9	7	0.6	52	1.2	20	0.9	12	0.7	5	0.5	28	1.0	55	1.1
Not eligible	1,300	85	1.0	21	1.1	3	0.5	63	1.3	13	0.9	13	0.9	3	0.5	36	1.3	49	1.4
School locale																			
City	1,100	75	1.4	18	1.3	6	0.8	53	1.6	23	1.3	11	1.0	6	0.7	25	1.3	59	1.5
Suburb	1,300	84	1.1	27	1.2	6	0.7	57	1.4	11	0.9	17	1.1	3	0.5	36	1.4	45	1.4
Town	300	81	2.2	26	2.4	5	1.1	55	2.7	14	1.9	5	1.2	3	0.9	24	2.4	68	2.5
Rural	600	81	1.7	12	1.4	4	0.8	63	2.0	21	1.7	7	1.1	4	0.8	36	2.0	53	2.1

Notes provided after Table C6.

Table C3. Access to Digital Technology at Home by Selected Student and School Characteristics: Grade 8

Student or School Characteristic	*N*	Wi-Fi or Internet		Smart-phone		Computer or Laptop: Both Own and Shared		Computer or Laptop: Own but Not Shared		Computer or Laptop: Shared but Not Own		Computer or Laptop: No Access		Tablet: Both Own and Shared		Tablet: Own but Not Shared		Tablet: Shared but Not Own		Tablet: No Access	
		%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Total	4,000	95	0.3	82	0.6	40	0.8	14	0.6	36	0.8	9	0.5	18	0.6	33	0.8	24	0.7	25	0.7
Sex																					
Male	2,100	95	0.5	80	0.9	41	1.1	16	0.8	34	1.0	10	0.6	19	0.9	32	1.0	24	0.9	25	0.9
Female	1,900	95	0.5	83	0.9	39	1.1	13	0.8	38	1.1	9	0.7	17	0.9	34	1.1	24	1.0	25	1.0
Race/ ethnicity																					
White	1,800	96	0.5	81	0.9	40	1.2	15	0.8	39	1.2	6	0.6	18	0.9	33	1.1	25	1.0	23	1.0
Black	700	95	0.8	86	1.3	38	1.8	15	1.3	35	1.8	13	1.2	18	1.5	38	1.9	19	1.5	25	1.6
Hispanic	1,200	93	0.7	82	1.1	40	1.5	13	1.0	34	1.4	14	1.0	17	1.2	29	1.3	25	1.3	29	1.3
Asian	200	98	0.9	74	3.0	53	3.4	14	2.4	32	3.2	1	0.8	24	3.0	26	3.1	33	3.2	17	2.6
Other	100	97	1.7	86	3.3	40	4.6	10	2.8	35	4.5	14	3.3	14	3.2	44	4.6	19	3.7	24	4.0
ELL status																					
ELL	300	91	1.8	71	2.7	37	2.9	14	2.1	31	2.8	17	2.2	19	2.4	27	2.7	25	2.6	29	2.7
Non-ELL	3,700	96	0.3	82	0.6	40	0.8	14	0.6	37	0.8	9	0.5	18	0.7	33	0.8	24	0.7	25	0.7
Disability status																					
SD	400	92	1.3	74	2.1	41	2.4	16	1.8	30	2.2	13	1.6	24	2.1	31	2.3	22	2.0	24	2.0
Non-SD	3,600	96	0.3	83	0.6	40	0.8	14	0.6	37	0.8	9	0.5	18	0.7	33	0.8	25	0.7	25	0.7
NSLP status																					
Eligible	2,300	93	0.6	81	0.8	37	1.0	14	0.8	34	1.0	14	0.7	17	0.8	32	1.0	22	0.9	29	1.0
Not eligible	1,700	99	0.3	83	0.9	44	1.2	14	0.9	39	1.2	3	0.4	19	1.0	33	1.2	27	1.1	20	1.0
School locale																					
City	1,100	95	0.7	79	1.2	40	1.5	14	1.1	35	1.4	12	1.0	19	1.2	33	1.5	23	1.3	25	1.3
Suburb	1,800	96	0.4	83	0.9	41	1.2	15	0.9	37	1.2	8	0.6	19	1.0	33	1.1	25	1.0	24	1.0
Town	400	94	1.2	77	2.2	35	2.5	13	1.8	41	2.6	10	1.6	16	1.9	30	2.4	30	2.4	24	2.2
Rural	800	94	0.8	83	1.3	42	1.7	15	1.3	34	1.7	8	1.0	16	1.3	34	1.7	22	1.5	28	1.6

Notes provided after Table C6.

Table C4. Access to Digital Technology at School by Selected Student and School Characteristics: Grade 8

Student or School Characteristic	N	Wi-Fi or Internet		Computer or Laptop: Both Own and Shared		Computer or Laptop: Own but Not Shared		Computer or Laptop: Shared but Not Own		Computer or Laptop: No Access		Tablet: Both Own and Shared		Tablet: Own but Not Shared		Tablet: Shared but Not Own		Tablet: No Access	
		%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Total	4,000	84	0.6	19	0.6	5	0.3	42	0.8	34	0.8	5	0.3	4	0.3	12	0.5	80	0.6
Sex																			
Male	2,100	84	0.8	20	0.9	6	0.5	39	1.1	36	1.0	6	0.5	4	0.4	12	0.7	79	0.9
Female	1,900	85	0.8	18	0.9	4	0.4	45	1.1	33	1.1	5	0.5	3	0.4	12	0.7	81	0.9
Race/ethnicity																			
White	1,800	85	0.7	18	0.7	4	0.4	42	0.9	35	0.9	5	0.4	3	0.3	12	0.6	80	0.7
Black	700	83	1.4	22	1.5	6	0.9	40	1.8	32	1.7	5	0.8	5	0.8	11	1.2	80	1.5
Hispanic	1,200	83	1.1	21	1.2	7	0.7	39	1.4	33	1.4	5	0.4	4	0.3	12	0.6	78	1.2
Asian	200	85	2.4	19	2.7	4	1.4	42	3.4	35	3.3	8	1.8	4	1.4	10	2.1	78	2.9
Other	100	81	3.6	19	3.6	4	1.8	40	4.6	38	4.5	6	2.2	3	1.6	11	2.9	81	3.7
ELL status																			
ELL	300	82	2.3	28	2.7	9	1.7	33	2.9	30	2.9	12	2.0	7	1.6	14	2.1	67	2.9
Non-ELL	3,700	85	0.6	18	0.6	5	0.3	42	0.8	35	0.8	5	0.3	4	0.3	11	0.5	81	0.7
Disability status																			
SD	400	83	1.8	29	2.2	7	1.3	38	2.3	27	2.1	11	1.5	7	1.3	15	1.7	67	2.3
Non-SD	3,600	85	0.6	18	0.6	5	0.4	42	0.8	35	0.8	4	0.3	3	0.3	11	0.5	81	0.7
NSLP status																			
Eligible	2,300	85	0.8	23	0.9	6	0.5	39	1.0	33	1.0	6	0.5	5	0.4	11	0.7	78	0.9
Not eligible	1,700	84	0.9	15	0.9	3	0.4	46	1.2	36	1.2	4	0.5	3	0.4	12	0.8	81	1.0
School locale																			
City	1,100	82	1.2	16	1.1	5	0.7	44	1.5	35	1.4	8	0.8	4	0.6	10	0.9	78	1.3
Suburb	1,800	83	0.9	18	0.9	5	0.5	40	1.2	37	1.2	4	0.5	4	0.5	13	0.8	79	1.0
Town	400	94	1.3	21	2.1	4	1.0	43	2.6	32	2.4	2	0.7	1	0.6	22	2.2	75	2.3
Rural	800	87	1.2	24	1.5	4	0.7	43	1.7	29	1.6	4	0.7	3	0.6	6	0.8	87	1.2

Notes provided after Table C6.

Table C5. Access to Digital Technology at Home by Selected Student and School Characteristics: Grade 12

Student or School Characteristic	N	Wi-Fi or Internet		Smart-phone		Computer or Laptop: Both Own and Shared		Computer or Laptop: Own but Not Shared		Computer or Laptop: Shared but Not Own		Computer or Laptop: No Access		Tablet: Both Own and Shared		Tablet: Own but Not Shared		Tablet: Shared but Not Own		Tablet: No Access	
		%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Total	3,800	95	0.3	92	0.4	52	0.8	17	0.6	25	0.7	6	0.4	15	0.6	22	0.7	27	0.7	36	0.8
Sex																					
Male	1,900	95	0.5	91	0.6	52	1.2	18	0.9	24	1.0	6	0.6	16	0.9	20	0.9	26	1.0	38	1.1
Female	1,900	96	0.5	93	0.6	52	1.2	17	0.9	25	1.0	6	0.6	14	0.9	24	1.0	28	1.1	33	1.1
Race/ ethnicity																					
White	1,800	98	0.4	92	0.7	53	1.2	17	0.9	26	1.1	4	0.4	14	0.8	23	1.0	28	1.1	35	1.1
Black	800	92	1.0	93	0.9	49	1.8	17	1.4	25	1.6	9	1.0	17	1.4	25	1.6	22	1.5	36	1.7
Hispanic	900	94	0.8	93	0.9	50	1.7	16	1.2	26	1.5	9	1.0	15	1.3	19	1.3	30	1.6	37	1.6
Asian	200	99	0.9	91	2.0	58	3.6	27	3.2	13	2.4	2	1.0	21	2.9	13	2.4	32	3.3	34	3.4
Other	200	90	2.3	92	2.1	51	3.8	18	2.9	19	2.9	12	2.4	16	2.7	22	3.1	26	3.3	35	3.6
ELL status																					
ELL	100	91	2.5	87	3.0	40	4.2	25	3.7	24	3.7	11	2.7	20	3.6	28	4.0	24	3.9	27	3.9
Non-ELL	3,700	95	0.3	92	0.4	52	0.8	17	0.6	25	0.7	6	0.4	15	0.6	22	0.7	27	0.7	36	0.8
Disability status																					
SD	300	92	1.5	85	2.0	44	2.9	22	2.4	28	2.5	6	1.4	21	2.4	25	2.5	22	2.4	31	2.6
Non-SD	3,500	96	0.4	93	0.4	52	0.9	17	0.6	25	0.7	6	0.4	15	0.6	22	0.7	27	0.8	36	0.8
NSLP status																					
Eligible	1,700	92	0.7	91	0.7	47	1.2	18	0.9	26	1.1	10	0.7	15	0.9	21	1.0	25	1.1	39	1.2
Not eligible	2,100	98	0.3	93	0.6	56	1.1	17	0.8	24	0.9	3	0.4	15	0.8	23	0.9	29	1.0	33	1.0
School locale																					
City	1,400	95	0.6	91	0.8	52	1.4	17	1.0	24	1.2	8	0.7	16	1.0	22	1.1	27	1.2	35	1.3
Suburb	1,500	97	0.4	94	0.6	50	1.3	18	1.0	27	1.2	5	0.6	14	0.9	21	1.1	28	1.2	37	1.3
Town	200	89	2.1	90	2.0	49	3.3	17	2.5	25	2.9	10	2.0	15	2.4	24	2.9	24	2.9	37	3.2
Rural	700	94	0.9	92	1.0	56	1.9	17	1.4	23	1.6	5	0.8	15	1.3	24	1.6	27	1.7	35	1.8

Notes provided after Table C6.

Table C6. Access to Digital Technology at School by Selected Student and School Characteristics: Grade 12

Student or School Characteristic	N	Wi-Fi or Internet		Computer or Laptop: Both Own and Shared		Computer or Laptop: Own but Not Shared		Computer or Laptop: Shared but Not Own		Computer or Laptop: No Access		Tablet: Both Own and Shared		Tablet: Own but Not Shared		Tablet: Shared but Not Own		Tablet: No Access	
		%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Total	3,800	85	0.6	14	0.6	3	0.3	42	0.8	41	0.8	4	0.3	2	0.2	9	0.5	86	0.6
Sex																			
Male	1,900	84	0.8	14	0.8	3	0.4	42	1.1	41	1.1	4	0.4	2	0.4	9	0.6	85	0.8
Female	1,900	86	0.8	14	0.8	3	0.4	42	1.1	42	1.1	3	0.4	2	0.3	8	0.6	87	0.8
Race/ethnicity																			
White	1,800	87	0.8	12	0.8	3	0.4	41	1.2	45	1.2	2	0.3	1	0.3	6	0.6	90	0.7
Black	800	84	1.3	17	1.4	3	0.6	48	1.8	32	1.7	4	0.7	3	0.6	13	1.2	80	1.4
Hispanic	900	81	1.3	14	1.2	4	0.7	39	1.7	43	1.7	5	0.7	2	0.5	8	0.9	85	1.2
Asian	200	84	2.6	16	2.6	3	1.1	41	3.5	41	3.5	7	1.7	3	1.1	8	1.9	83	2.7
Other	200	81	2.9	9	2.2	4	1.5	43	3.7	43	3.7	6	1.8	2	1.1	12	2.5	80	3.0
ELL status																			
ELL	100	85	3.2	26	3.7	7	2.3	39	4.1	27	3.8	8	2.3	2	1.2	13	2.8	77	3.6
Non-ELL	3,700	85	0.6	13	0.6	3	0.3	42	0.8	42	0.8	3	0.3	2	0.2	8	0.5	86	0.6
Disability status																			
SD	300	85	2.1	21	2.3	4	1.1	38	2.8	37	2.7	6	1.3	2	0.9	13	1.9	79	2.3
Non-SD	3,500	85	0.6	13	0.6	3	0.3	42	0.8	42	0.8	3	0.3	2	0.2	8	0.5	87	0.6
NSLP status																			
Eligible	1,700	82	0.9	18	0.9	4	0.5	43	1.2	35	1.2	5	0.5	2	0.4	10	0.7	83	0.9
Not eligible	2,100	86	0.8	10	0.7	3	0.3	41	1.1	46	1.1	3	0.3	2	0.3	7	0.6	89	0.7
School locale																			
City	1,400	83	1.0	13	0.9	3	0.5	46	1.3	38	1.3	4	0.5	2	0.4	10	0.8	84	1.0
Suburb	1,500	85	0.9	6	0.6	3	0.4	45	1.3	46	1.3	2	0.4	2	0.4	7	0.7	89	0.8
Town	200	82	2.5	28	3.0	4	1.2	31	3.1	37	3.2	3	1.1	2	0.9	7	1.8	88	2.2
Rural	700	87	1.3	27	1.7	3	0.6	31	1.7	39	1.8	5	0.8	2	0.6	10	1.1	82	1.4

NOTE: Sample size is rounded to nearest hundred. Detail may not sum to totals because of rounding and because the "Information not available" category for the National School Lunch Program, which provides free or reduced-price lunches, is not displayed.
SE=standard error; ELL=English language learner; SD=student with disability; NSLP=National School Lunch Program.

Appendix D. Exploratory and Confirmatory Factor Analysis Results—Common Items

Access Domain

Table D1. Structure of Computer Access Student Contextual Questionnaire: Grade 4

	Exploratory Factor Analysis		**Confirmatory Factor Analysis**	
Root Mean Square Error of Approximation	0.047		0.037	
Comparative Fit Index	0.950		0.950	
Tucker-Lewis Index	0.869		0.919	
	Home Access	**School Access**	**Home Access**	**School Access**
Computer access at home[1]	0.68	0.00	0.67	
Tablet access at home[1]	0.41	0.01	0.42	
Q06: Have Wi-Fi or Internet connection at home	0.62	-0.05	0.59	
Q07: Have a smartphone	0.37	0.12	0.44	
Computer access at school[2]	0.02	0.44		0.47
Tablet access at school[2]	-0.04	0.60		0.53
Q22: Have Wi-Fi or Internet connection at school	0.03	0.48		0.53

[1] Two items were combined into one: (a) device available for only student's use at home or device available for both student's use and shared use at home, (b) device available for student to share at home, and (c) device not available for student's use at home.
[2] Two items were combined into one: (a) device available for only student's use at school or device available for both student's use and shared use at school, (b) device available for student to share at school, and (c) device not available for student's use at school.

Table D2. Structure of Computer Access Student Contextual Questionnaire: Grade 8

	Exploratory Factor Analysis		**Confirmatory Factor Analysis**	
Root Mean Square Error of Approximation	0.022		0.021	
Comparative Fit Index	0.983		0.973	
Tucker-Lewis Index	0.955		0.957	
	Home Access	**School Access**	**Home Access**	**School Access**
Computer access at home[1]	0.65	0.10	0.67	
Tablet access at home[1]	0.31	0.00	0.31	
Q02_e: Have Wi-Fi or Internet connection at home	0.72	-0.04	0.69	
Q02_f: Have a smartphone	0.29	0.08	0.30	
Computer access at school[2]	0.00	0.83		0.78
Tablet access at school[2]	0.01	0.42		0.44
Q09_c: Have Wi-Fi or Internet connection at school	0.05	0.35		0.36

[1] Two items were combined into one: (a) device available for only student's use at home or device available for both student's use and shared use at home, (b) device available for student to share at home, and (c) device not available for student's use at home.
[2] Two items were combined into one: (a) device available for only student's use at school or device available for both student's use and shared use at school, (b) device available for student to share at school, and (c) device not available for student's use at school.

Table D3. Structure of Computer Access Student Contextual Questionnaire: Grade 12

	Exploratory Factor Analysis		Confirmatory Factor Analysis	
Root Mean Square Error of Approximation	0.023		0.031	
Comparative Fit Index	0.986		0.958	
Tucker-Lewis Index	0.964		0.932	
	Home Access	**School Access**	**Home Access**	**School Access**
Computer access at home[1]	0.61	0.10	0.63	
Tablet access at home[1]	0.30	0.10	0.30	
Q02-e: Have Wi-Fi or Internet connection at home	0.93	-0.01	0.88	
Q02-f: Have a smartphone	0.42	0.01	0.42	
Computer access at school[2]	-0.01	0.81		0.82
Tablet access at school[2]	0.02	0.53		0.52
Q09-c: Have Wi-Fi or Internet connection at school	0.14	0.38		0.37

[1] Two items were combined into one: (a) device available for only student's use at home or device available for both student's use and shared use at home, (b) device available for student to share at home, and (c) device not available for student's use at home.

[2] Two items were combined into one: (a) device available for only student's use at school or device available for both student's use and shared use at school, (b) device available for student to share at school, and (c) device not available for student's use at school.

Familiarity Domain

Table D4. Structure of Computer Familiarity Student Contextual Questionnaire: Grade 4

	Exploratory Factor Analysis			Confirmatory Factor Analysis		
Root Mean Square Error of Approximation	0.070			0.080		
Comparative Fit Index	0.902			0.893		
Tucker-Lewis Index	0.867			0.876		
	Instruction	**Computer Use**	**Tablet Use**	**Instruction**	**Computer Use**	**Tablet Use**
Q13: At school: were taught how to type on a computer keyboard	0.58	-0.16	0.01	0.43		
Q14: At school: were taught how to write sentences and paragraphs using a computer	0.78	0.02	-0.10	0.65		
Q15: At school: were taught how to edit text using a computer	0.68	0.08	0.01	0.71		
Q16: At school: were taught how to search for information on the Internet	0.60	-0.04	0.00	0.54		
Q17: At school: were taught how to use a tablet	0.31	-0.23	0.55	0.68		
Q19: At school: were taught how to look up the meaning of a word using a computer	0.55	0.09	0.02	0.61		
Q27: How often used a laptop or desktop: to write a short paper for school	0.31	0.54	-0.05		0.63	
Q28: How often used a laptop or desktop: to write a long paper for school	0.29	0.53	0.02		0.67	
Q29: How often used a laptop or desktop: to search the Internet for a school project	0.20	0.45	0.11		0.62	
Q30: How often used a laptop or desktop: to practice math	0.05	0.56	0.13		0.66	
Q31: How often used a laptop or desktop: to practice reading	0.01	0.56	0.20		0.69	
Q32: How often used a laptop or desktop: to take a test	0.13	0.37	-0.01		0.41	
Q33: How often used a tablet: to write a short paper for school	0.05	-0.04	0.80			0.80
Q34: How often used a tablet: to write a long paper for school	0.04	0.01	0.83			0.85
Q35: How often used a tablet: to search the Internet for a school project	0.06	0.01	0.73			0.76
Q36: How often used a tablet: to practice math	-0.06	0.07	0.79			0.81
Q37: How often used a tablet: to practice reading	-0.10	0.07	0.84			0.85
Q38: How often used a tablet: to take a test	0.01	-0.11	0.78			0.71
Q11: Weekday: hours using a laptop or desktop for school[1]	-0.12	0.50	0.15			
Q12: Weekday: hours using a tablet for school[1]	-0.20	0.44	0.29			
Q18: At school: were taught how to draw a picture using a computer[1]	0.43	0.01	0.18			
Q23: At school: most teachers use computers when teaching[1]	0.19	0.06	0.00			
Q24: At school: most teachers require us to use computers in the classroom[1]	0.12	0.38	-0.09			

[1]Items were excluded from the confirmatory factor analysis based on the exploratory factor analysis and reliability analysis results.

Table D5. Structure of Computer Familiarity Student Contextual Questionnaire: Grade 8 Common Confirmatory Factor Analysis Set Results

	Exploratory Factor Analysis				Confirmatory Factor Analysis				
Root Mean Square Error of Approximation	0.058				0.062				
Comparative Fit Index	0.915				0.950				
Tucker-Lewis Index	0.902				0.946				
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q08-a: At school: were taught how to type on a computer keyboard	0.54	0.16	-0.08	-0.03	0.55				
Q08-b: At school: were taught how to write sentences and paragraphs using a computer	0.76	0.17	-0.04	-0.15	0.84				
Q08-c: At school: were taught how to edit text using a computer	0.75	0.23	-0.08	-0.08	0.77				
Q08-d: At school: were taught how to search for information on the Internet	0.83	-0.02	-0.06	-0.15	0.88				
Q08-e: At school: were taught how to use a tablet	0.54	-0.20	0.29	0.00	0.64				
Q08-g: At school: were taught how to look up the meaning of a word using a computer	0.83	0.00	0.01	-0.18	0.87				
Q08-h: At school: were taught how to create a spreadsheet using a computer[1]	0.52	0.19	0.03	0.26					
Q08-i: At school: were taught how to create a presentation using a computer[1]	0.58	0.34	-0.09	-0.07					
Q08-j: At school: were taught how to run simulations using a computer[1]	0.45	0.00	0.14	0.27					
Q08-k: At school: were taught how to write a computer program or app[1]	0.45	-0.08	0.19	0.27					
Q08-l: At school: were taught how to create a graph or chart using a computer[1]	0.56	0.23	0.04	0.16					
Q08-m: At school: were taught how to maintain a website or blog[1]	0.50	-0.10	0.23	0.12					
Q08-n: At school: were taught how to install new software or apps[1]	0.64	-0.10	0.17	0.15					
Q08-o: At school: were taught how to troubleshoot problems with a computer[1]	0.53	-0.05	0.14	0.29					
Q12-a: How often used a laptop or desktop: to write a short paper for school	-0.06	0.78	0.50	-0.04		0.73			
Q12-b: How often used a laptop or desktop: to write a long paper for school	-0.10	0.74	0.55	0.00		0.76			

	Exploratory Factor Analysis				Confirmatory Factor Analysis				
Root Mean Square Error of Approximation	0.058				0.062				
Comparative Fit Index	0.915				0.950				
Tucker-Lewis Index	0.902				0.946				
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q12-c: How often used a laptop or desktop: to search the Internet for a school project	-0.03	0.64	0.47	-0.02		0.63			
Q12-d: How often used a laptop or desktop: to practice math	0.03	0.41	0.62	-0.03		0.71			
Q12-e: How often used a laptop or desktop: to practice reading	0.06	0.40	0.69	-0.02		0.79			
Q12-f: How often used a laptop or desktop: to take a test	0.04	0.39	0.51	-0.07		0.55			
Q12-g: How often used a laptop or desktop: to create a map[1]	0.11	0.17	0.67	0.14					
Q12-h: How often used a laptop or desktop: to work on a website or blog[1]	0.15	0.05	0.55	0.13					
Q12-i: How often used a laptop or desktop: to create a multimedia presentation on your own[1]	0.09	0.54	0.52	0.08					
Q12-j: How often used a laptop or desktop: to work with a team to create a multimedia presentation[1]	0.07	0.51	0.59	0.02					
Q13-a: How often used a tablet: to write a short paper for school	-0.12	-0.06	0.91	0.01			0.94		
Q13-b: How often used a tablet: to write a long paper for school	-0.11	-0.10	0.92	0.03			0.95		
Q13-c: How often used a tablet: to search the Internet for a school project	-0.09	0.05	0.82	-0.06			0.80		
Q13-d: How often used a tablet: to practice math	-0.05	-0.01	0.88	-0.03			0.89		
Q13-e: How often used a tablet: to practice reading	-0.01	-0.02	0.90	-0.01			0.92		
Q13-f: How often used a tablet: to take a test	-0.06	-0.05	0.82	-0.06			0.63		
Q13-g: How often used a tablet: to create a map[1]	0.08	-0.12	0.83	0.10					
Q13-h: How often used a tablet: to work on a website or blog[1]	0.05	-0.11	0.77	0.10					
Q13-i: How often used a tablet: to create a multimedia presentation on your own[1]	0.02	0.01	0.88	0.05					

	Exploratory Factor Analysis				Confirmatory Factor Analysis				
Root Mean Square Error of Approximation	0.058				0.062				
Comparative Fit Index	0.915				0.950				
Tucker-Lewis Index	0.902				0.946				
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q13-j: How often used a tablet: to work with a team to create a multimedia presentation[1]	0.03	0.00	0.88	0.01					
Q23-a: How familiar with e-reader	-0.01	0.19	-0.09	0.51				0.50	
Q23-c: How familiar with firewall	0.01	0.19	-0.16	0.66				0.63	
Q23-d: How familiar with hyperlink	0.08	0.23	-0.09	0.69				0.69	
Q23-f: How familiar with instant messaging	0.00	0.37	-0.22	0.41				0.39	
Q23-g: How familiar with CPU	0.00	0.13	-0.11	0.64				0.62	
Q23-h: How familiar with track changes	0.00	0.01	0.06	0.79				0.81	
Q23-k: How familiar with pivot table	0.02	-0.08	0.06	0.85				0.88	
Q23-l: How familiar with spreadsheet	0.17	0.30	-0.10	0.55				0.56	
Q23-o: How familiar with cloud computing	-0.01	0.14	-0.06	0.75				0.74	
Q23-p: How familiar with server	-0.01	0.32	-0.20	0.58				0.56	
Q23-q: How familiar with root directory	-0.01	0.08	-0.04	0.81				0.80	
Q23-r: How familiar with compiler	-0.04	0.02	0.02	0.88				0.89	
Q23-s: How familiar with ASCII	-0.04	-0.08	0.05	0.91				0.93	
Q23-e: How familiar with neuro-digital computing	-0.02	0.02	0.05	0.81					0.83
Q23-j: How familiar with pyramidal browser	0.01	-0.09	0.08	0.83					0.86
Q23-m: How familiar with limbic wire	-0.01	-0.11	0.11	0.89					0.93
Q23-n: How familiar with spinalbyte	-0.02	-0.13	0.07	0.90					0.93
Q23-t: How familiar with callosum board	-0.02	-0.11	0.06	0.89					0.92
Q06: Weekday: hours using a laptop or desktop for school[2]	-0.02	0.22	0.25	0.13					
Q07: Weekday: hours using a tablet for school[2]	-0.01	0.01	0.36	0.10					
Q08-f: At school: were taught how to draw a picture using a computer[2]	0.59	-0.02	0.11	0.10					
Q09-d: At school: most teachers use computers when teaching[2]	0.05	0.25	-0.03	0.01					
Q09-e: At school: most teachers require us to use computers in the classroom[2]	0.12	0.14	0.39	-0.02					
Q23-b: How familiar with Wi-Fi[2]	0.01	0.45	-0.29	0.15					
Q23-i: How familiar with cut and paste[2]	-0.03	0.54	-0.27	0.27					

[1] Confirmatory factor analysis results with a full set of items are presented in Appendix E.
[2] Items were excluded from the confirmatory factor analysis based on the exploratory factor analysis and reliability analysis results.

Table D6. Structure of Computer Familiarity Student Contextual Questionnaire: Grade 12 Common Confirmatory Analysis Set Results

	Exploratory Factor Analysis				Confirmatory Factor Analysis				
Root Mean Square Error of Approximation	0.056				0.073				
Comparative Fit Index	0.910				0.920				
Tucker-Lewis Index	0.896				0.914				
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q08-a: At school: were taught how to type on a computer keyboard	0.58	-0.02	0.11	-0.10	0.61				
Q08-b: At school: were taught how to write sentences and paragraphs using a computer	0.83	-0.03	0.04	-0.20	0.87				
Q08-c: At school: were taught how to edit text using a computer	0.87	-0.06	0.07	-0.21	0.89				
Q08-d: At school: were taught how to search for information on the Internet	0.86	0.01	-0.05	-0.24	0.87				
Q08-e: At school: were taught how to use a tablet	0.52	0.46	-0.18	-0.02	0.61				
Q08-g: At school: were taught how to look up the meaning of a word using a computer	0.85	0.07	-0.03	-0.22	0.88				
Q08-h: At school: were taught how to create a spreadsheet using a computer[1]	0.57	0.00	0.26	0.11					
Q08-i: At school: were taught how to create a presentation using a computer[1]	0.79	-0.12	0.17	-0.14					
Q08-j: At school: were taught how to run simulations using a computer[1]	0.49	0.24	0.07	0.17					
Q08-k: At school: were taught how to write a computer program or app[1]	0.44	0.32	-0.05	0.18					
Q08-l: At school: were taught how to create a graph or chart using a computer[1]	0.62	-0.04	0.24	0.10					
Q08-m: At school: were taught how to maintain a website or blog[1]	0.52	0.35	0.06	0.05					
Q08-n: At school: were taught how to install new software or apps[1]	0.74	0.33	-0.08	0.10					
Q08-o: At school: were taught how to troubleshoot problems with a computer[1]	0.68	0.31	-0.04	0.18					
Q12-a: How often used a laptop or desktop: to write a short paper for school	-0.16	0.21	0.81	-0.05		0.80			
Q12-b: How often used a laptop or desktop: to write a long paper for school	-0.19	0.23	0.80	-0.05		0.79			

	Exploratory Factor Analysis				Confirmatory Factor Analysis				
Root Mean Square Error of Approximation	0.056				0.073				
Comparative Fit Index	0.910				0.920				
Tucker-Lewis Index	0.896				0.914				
	Instruction	Computer Use	Tablet Use	Concept	Instruction	Computer Use	Tablet Use	Concept	Over-claiming
Q12-c: How often used a laptop or desktop: to search the Internet for a school project	-0.11	0.17	0.72	-0.05		0.64			
Q12-d: How often used a laptop or desktop: to practice math	0.02	0.51	0.40	-0.03		0.72			
Q12-e: How often used a laptop or desktop: to practice reading	0.05	0.61	0.38	-0.07		0.78			
Q12-f: How often used a laptop or desktop: to take a test	0.07	0.37	0.28	0.00		0.50			
Q12-g: How often used a laptop or desktop: to create a map[1]	0.12	0.71	0.20	0.06					
Q12-h: How often used a laptop or desktop: to work on a website or blog[1]	0.07	0.54	0.22	0.04					
Q12-i: How often used a laptop or desktop: to create a multimedia presentation on your own[1]	0.03	0.36	0.62	0.03					
Q12-j: How often used a laptop or desktop: to work with a team to create a multimedia presentation[1]	0.04	0.38	0.60	0.01					
Q13-a: How often used a tablet: to write a short paper for school	-0.11	0.93	-0.01	0.04			0.96		
Q13-b: How often used a tablet: to write a long paper for school	-0.10	0.95	-0.03	0.03			0.96		
Q13-c: How often used a tablet: to search the Internet for a school project	-0.09	0.82	0.12	-0.03			0.85		
Q13-d: How often used a tablet: to practice math	0.00	0.91	0.06	-0.01			0.93		
Q13-e: How often used a tablet: to practice reading	0.00	0.93	0.05	-0.03			0.94		
Q13-f: How often used a tablet: to take a test	0.02	0.83	-0.01	-0.03			0.83		
Q13-g: How often used a tablet: to create a map[1]	0.11	0.90	-0.03	0.11					
Q13-h: How often used a tablet: to work on a website or blog[1]	0.06	0.85	0.00	0.09					
Q13-i: How often used a tablet: to create a multimedia presentation on your own[1]	0.03	0.92	0.07	0.07					

	Exploratory Factor Analysis				Confirmatory Factor Analysis				
Root Mean Square Error of Approximation	0.056				0.073				
Comparative Fit Index	0.910				0.920				
Tucker-Lewis Index	0.896				0.914				
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q13-j: How often used a tablet: to work with a team to create a multimedia presentation[1]	0.04	0.90	0.08	0.06					
Q23-a: How familiar with e-reader	-0.08	-0.13	0.26	0.53				0.55	
Q23-c: How familiar with firewall	-0.02	-0.26	0.19	0.66				0.65	
Q23-d: How familiar with hyperlink	0.07	-0.23	0.29	0.58				0.62	
Q23-f: How familiar with instant messaging	0.01	-0.48	0.42	0.39				0.43	
Q23-g: How familiar with CPU	0.02	-0.14	0.11	0.65				0.64	
Q23-h: How familiar with track changes	0.02	0.12	0.03	0.71				0.75	
Q23-k: How familiar with pivot table	0.05	0.18	-0.05	0.80				0.88	
Q23-l: How familiar with spreadsheet	0.11	-0.26	0.40	0.49				0.57	
Q23-o: How familiar with cloud computing	-0.04	-0.10	0.14	0.74				0.74	
Q23-p: How familiar with server	0.03	-0.33	0.29	0.63				0.66	
Q23-q: How familiar with root directory	-0.01	0.00	0.07	0.77				0.78	
Q23-r: How familiar with compiler	-0.04	0.00	0.05	0.84				0.84	
Q23-s: How familiar with ASCII	-0.09	0.12	-0.03	0.87				0.90	
Q23-e: How familiar with neuro-digital computing	-0.01	0.15	0.02	0.76					0.81
Q23-j: How familiar with pyramidal browser	0.02	0.19	-0.09	0.80					0.86
Q23-m: How familiar with limbic wire	0.01	0.21	-0.11	0.85					0.91
Q23-n: How familiar with spinalbyte	-0.02	0.23	-0.15	0.87					0.94
Q23-t: How familiar with callosum board	-0.03	0.24	-0.12	0.83					0.91
Q06: Weekday: hours using a laptop or desktop for school[2]	-0.10	0.15	0.37	0.09					
Q07: Weekday: hours using a tablet for school[2]	-0.04	0.50	0.10	0.06					
Q08-f: At school: were taught how to draw a picture using a computer[2]	0.62	0.16	0.02	0.00					
Q09-d: At school: most teachers use computers when teaching[2]	0.06	-0.07	0.17	0.08					
Q09-e: At school: most teachers require us to use computers in the classroom[2]	0.17	0.39	0.12	-0.02					
Q23-b: How familiar with Wi-Fi[2]	0.06	-0.56	0.46	0.23					
Q23-i: How familiar with cut and paste[2]	0.03	-0.57	0.50	0.21					

[1] Confirmatory factor analysis results with a full set of items are presented in Appendix E.
[2] Items were excluded from the confirmatory factor analysis based on the exploratory factor analysis and reliability analysis results.

Self-Efficacy Domain

Table D7. Structure of Computer Self-Efficacy Student Contextual Questionnaire: Grades 4, 8, and 12

	Grade 4	Grade 8		Grade 12	
	Confirmatory Factor Analysis	Confirmatory Factor Analysis: Full Set	Confirmatory Factor Analysis: Common Set	Confirmatory Factor Analysis: Full Set	Confirmatory Factor Analysis: Common Set
Root Mean Square Error of Approximation	0.068	0.136	0.094	0.116	0.035
Comparative Fit Index	0.987	0.887	0.992	0.931	0.999
Tucker-Lewis Index	0.974	0.871	0.985	0.921	0.999
Q42/ Q17-a: Able to write sentences and paragraphs using a computer	0.75	0.84	0.92	0.92	0.96
Q43/ Q17-b: Able to edit text using a computer	0.74	0.81	0.87	0.90	0.94
Q44/ Q17-c: Able to use a touchscreen	0.68	0.80	0.87	0.89	0.93
Q45/ Q17-d: Able to look up the meaning of a word using a computer	0.69	0.90	0.94	0.98	0.97
Q46/ Q17-e: Able to draw a picture using a computer	0.52	0.68	0.57	0.71	0.65
Q17-f: Able to view or download digital media		0.80		0.84	
Q17-g: Able to create a presentation using a computer[1]		0.77		0.90	
Q17-h: Able to create a spreadsheet using a computer[1]		0.72		0.74	
Q17-i: Able to install new software or apps[1]		0.77		0.78	
Q17-j: Able to participate in online discussions, forums, social networking sites[1]		0.75		0.80	
Q17-k: Able to maintain a website or blog[1]		0.68		0.70	
Q17-l: Able to search for information on the Internet[1]		0.81		0.91	
Q17-m: Able to run simulations using a computer[1]		0.78		0.74	
Q17-n: Able to create a graph or chart using a computer[1]		0.75		0.79	
Q17-o: Able to write a computer program or app[1]		0.75		0.65	
Q17-p: Able to troubleshoot a problem with a computer[1]		0.77		0.76	
Q17-q: Able to figure out how to use new functions of digital devices[1]		0.73		0.75	

[1] Confirmatory factor analysis results with a full set of items are presented in Appendix E.

Appendix E. Confirmatory Factor Analysis Results—Full Set of Items

Table E1. Structure of Computer Familiarity Student Contextual Questionnaire: Grades 8 and 12 Confirmatory Factor Analysis Full-Set Results

	Grade 8					Grade 12				
Root Mean Square Error of Approximation	0.066					0.070				
Comparative Fit Index	0.898					0.876				
Tucker-Lewis Index	0.893					0.870				
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q08-a: At school: were taught how to type on a computer keyboard	0.39					0.50				
Q08-b: At school: were taught how to write sentences and paragraphs using a computer	0.58					0.71				
Q08-c: At school: were taught how to edit text using a computer	0.58					0.76				
Q08-d: At school: were taught how to search for information on the Internet	0.61					0.70				
Q08-e: At school: were taught how to use a tablet	0.63					0.66				
Q08-g: At school: were taught how to look up the meaning of a word using a computer	0.63					0.72				
Q08-h: At school: were taught how to create a spreadsheet using a computer	0.67					0.66				
Q08-i: At school: were taught how to create a presentation using a computer	0.44					0.68				
Q08-j: At school: were taught how to run simulations using a computer	0.70					0.70				
Q08-k: At school: were taught how to write a computer program or app	0.73					0.68				

	Grade 8					Grade 12				
Root Mean Square Error of Approximation	0.066					0.070				
Comparative Fit Index	0.898					0.876				
Tucker-Lewis Index	0.893					0.870				
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q08-l: At school: were taught how to create a graph or chart using a computer	0.65					0.68				
Q08-m: At school: were taught how to maintain a website or blog	0.67					0.72				
Q08-n: At school: were taught how to install new software or apps	0.75					0.86				
Q08-o: At school: were taught how to troubleshoot problems with a computer	0.78					0.86				
Q12-a: How often used a laptop or desktop: to write a short paper for school		0.62					0.69			
Q12-b: How often used a laptop or desktop: to write a long paper for school		0.67					0.68			
Q12-c: How often used a laptop or desktop: to search the Internet for a school project		0.55					0.58			
Q12-d: How often used a laptop or desktop: to practice math		0.66					0.67			
Q12-e: How often used a laptop or desktop: to practice reading		0.74					0.75			
Q12-f: How often used a laptop or desktop: to take a test		0.53					0.51			
Q12-g: How often used a laptop or desktop: to create a map		0.85					0.91			
Q12-h: How often used a laptop or desktop: to work on a website or blog		0.70					0.66			
Q12-i: How often used a laptop or desktop: to create a multimedia presentation on your own		0.68					0.72			
Q12-j: How often used a laptop or desktop: to work with a team to create a multimedia presentation		0.69					0.72			

	Grade 8					Grade 12				
Root Mean Square Error of Approximation			0.066					0.070		
Comparative Fit Index			0.898					0.876		
Tucker-Lewis Index			0.893					0.870		
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q13-a: How often used a tablet: to write a short paper for school			0.92					0.94		
Q13-b: How often used a tablet: to write a long paper for school			0.94					0.95		
Q13-c: How often used a tablet: to search the Internet for a school project			0.79					0.83		
Q13-d: How often used a tablet: to practice math			0.87					0.91		
Q13-e: How often used a tablet: to practice reading			0.91					0.93		
Q13-f: How often used a tablet: to take a test			0.81					0.83		
Q13-g: How often used a tablet: to create a map			0.92					0.94		
Q13-h: How often used a tablet: to work on a website or blog			0.85					0.89		
Q13-i: How often used a tablet: to create a multimedia presentation on your own			0.91					0.94		
Q13-j: How often used a tablet: to work with a team to create a multimedia presentation			0.89					0.93		
Q23-a: How familiar with e-reader				0.50					0.54	
Q23-c: How familiar with firewall				0.63					0.64	
Q23-d: How familiar with hyperlink				0.69					0.62	
Q23-f: How familiar with instant messaging				0.37					0.41	
Q23-g: How familiar with CPU				0.62					0.64	
Q23-h: How familiar with track changes				0.82					0.76	
Q23-k: How familiar with pivot table				0.88					0.88	
Q23-l: How familiar with spreadsheet				0.58					0.58	

	Grade 8					Grade 12				
Root Mean Square Error of Approximation	0.066					0.070				
Comparative Fit Index	0.898					0.876				
Tucker-Lewis Index	0.893					0.870				
	Instruction	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**	**Instruction**	**Computer Use**	**Tablet Use**	**Concept**	**Over-claiming**
Q23-o: How familiar with cloud computing				0.74					0.73	
Q23-p: How familiar with server				0.54					0.65	
Q23-q: How familiar with root directory				0.80					0.78	
Q23-r: How familiar with compiler				0.89					0.84	
Q23-s: How familiar with ASCII				0.94					0.90	
Q23-e: How familiar with neuro-digital computing					0.82					0.81
Q23-j: How familiar with pyramidal browser					0.86					0.86
Q23-m: How familiar with limbic wire					0.93					0.91
Q23-n: How familiar with spinalbyte					0.93					0.93
Q23-t: How familiar with callosum board					0.92					0.91
Q06: Weekday: hours using a laptop or desktop for school[1]										
Q07: Weekday: hours using a tablet for school[1]										
Q08-f: At school: were taught how to draw a picture using a computer[1]										
Q09-d: At school: most teachers use computers when teaching[1]										
Q09-e: At school: most teachers require us to use computers in the classroom[1]										
Q23-b: How familiar with Wi-Fi[1]										
Q23-i: How familiar with cut and paste[1]										

[1] Items were excluded from the confirmatory factor analysis based on the exploratory factor analysis and reliability analysis results.

Table E2. Computer Access and Familiarity Indices Correlations and Reliability: Grade 8 Full Set

	Access		Familiarity				Self-Efficacy
	Home Access	School Access	Instruction	Computer Use	Tablet Use	Concept	
Home Access	1.00						
School Access	0.03	1.00					
Instruction	0.10	0.19	1.00				
Computer Use	0.09	0.30	0.31	1.00			
Tablet Use	0.05	0.29	0.21	0.48	1.00		
Concept	0.09	-0.07	0.01	-0.07	-0.21	1.00	
Self-Efficacy	0.18	0.04	0.23	0.17	0.01	0.24	1.00
Reliability	0.35	0.35	0.79	0.84	0.93	0.89	0.92

Table E3. Computer Access and Familiarity Indices Correlations and Reliability: Grade 12 Full Set

	Access		Familiarity				Self-Efficacy
	Home Access	School Access	Instruction	Computer Use	Tablet Use	Concept	
Home Access	1.00						
School Access	0.04	1.00					
Instruction	0.07	0.22	1.00				
Computer Use	0.06	0.24	0.27	1.00			
Tablet Use	0.04	0.19	0.20	0.45	1.00		
Concept	0.07	-0.03	-0.02	-0.05	-0.22	1.00	
Self-Efficacy	0.19	0.04	0.20	0.18	-0.04	0.30	1.00
Reliability	0.40	0.37	0.82	0.84	0.94	0.88	0.93

Appendix F. Regression Results for Digitally Based Assessment (DBA) and Paper-Based Assessment (PBA) Samples

Table F1. Regression-Estimated Relationship Between Indices and NAEP Mathematics Achievement for the DBA and PBA Samples, and the Difference Between the Two Samples (DBA – PBA)

	Mathematics			Reading		
	PBA	DBA	DBA – PBA	PBA	DBA	DBA – PBA
Grade 4						
Access						
Home Access	-0.09	-0.03	0.06	0.11	0.03	-0.08
School Access	0.03	-0.37 *	-0.40 *	0.05	-0.38	-0.43 *
Familiarity						
Instruction	0.02	0.01	-0.01	0.08	0.34	0.26
Computer Use	-0.39 *	-0.6 *	-0.21	-0.48 *	-0.62 *	-0.14
Tablet Use	-0.54 *	-0.99 *	-0.45 *	-0.73 *	-1.21 *	-0.48 *
Self-Efficacy						
Self-Efficacy	0.72 *	0.79 *	0.07	1.23 *	1.08 *	-0.15
Grade 8						
Access						
Home Access	0.40 *	0.30	-0.10	0.31 *	0.29	-0.02
School Access	-0.54 *	-0.55 *	-0.01	-0.73 *	-0.30	0.43 *
Familiarity						
Instruction	-0.29 *	0.08	0.37	-0.20	0.06	0.26
Computer Use	-0.32 *	-0.41	-0.09	-0.30 *	-0.39 *	-0.09
Tablet Use	-0.81 *	-0.96 *	-0.15	-0.99 *	-0.98 *	0.01
Digital Concepts	1.52 *	1.61 *	0.09	1.43 *	1.46 *	0.03
Self-Efficacy						
Self-Efficacy	1.17 *	1.01 *	-0.16	1.22 *	1.45 *	0.23
Grade 12						
Access						
Home Access	0.12	0.29	0.17	0.29	0.63	0.34 *
School Access	-0.40 *	-0.44 *	-0.04	-0.34 *	-0.43 *	-0.09
Familiarity						
Instruction	-0.35 *	-0.26	0.09	-0.38 *	-0.24	0.14
Computer Use	-0.02	0.12	0.14	0.09	-0.03	-0.12
Tablet Use	-0.64 *	-0.71 *	-0.07	-0.87 *	-0.82 *	0.05
Digital Concepts	1.32 *	1.47 *	0.15	1.64 *	1.90 *	0.26
Self-Efficacy						
Self-Efficacy	0.95 *	1.16 *	0.21	1.37 *	1.46 *	0.09

* Statistically significant, $p < .05$.

Table F2. Regression-Estimated Relationship Between Indices and NAEP Mathematics Achievement for the DBA and PBA Samples, and the Difference Between the Two Samples (DBA – PBA) Using a Model That Accounts for Differences in Student Characteristics

	Mathematics			Reading		
	PBA	**DBA**	**DBA – PBA**	**PBA**	**DBA**	**DBA – PBA**
Grade 4						
Access						
Home Access	-0.09	-0.13	-0.04	0.05	0.03	-0.02
School Access	-0.08	-0.26 *	-0.18	-0.01	-0.19	-0.18
Familiarity						
Instruction	-0.10	-0.16	-0.06	-0.04	0.21	0.25
Computer Use	-0.25 *	-0.42 *	-0.17	-0.35 *	-0.33 *	0.02
Tablet Use	-0.35 *	-0.67 *	-0.32	-0.51 *	-0.62 *	-0.11
Self-Efficacy						
Self-Efficacy	0.39 *	0.43 *	0.04	0.66 *	0.55 *	-0.11
Grade 8						
Access						
Home Access	0.04	0.12	0.08	0.04	0.15	0.11
School Access	-0.23	-0.37 *	-0.14	-0.34 *	-0.26	0.08
Familiarity						
Instruction	-0.24 *	0.06	0.30	-0.16	-0.02	0.14
Computer Use	-0.15	-0.12	0.03	-0.02	-0.17	-0.15
Tablet Use	-0.51 *	-0.46 *	0.05	-0.48 *	-0.60 *	-0.12
Digital Concepts	1.03 *	0.82 *	-0.21	0.84 *	0.96 *	0.12
Self-Efficacy						
Self-Efficacy	0.69 *	0.53 *	-0.16	0.67 *	0.92 *	0.25
Grade 12						
Access						
Home Access	0.02	0.13	0.11	0.10	0.29	0.19
School Access	-0.22	-0.07	0.15	-0.17	-0.16	0.01
Familiarity						
Instruction	-0.31 *	-0.15	0.16	-0.28 *	-0.16	0.12
Computer Use	0.12	0.19	0.07	0.18	0.12	-0.06
Tablet Use	-0.34 *	-0.21	0.13	-0.46 *	-0.33 *	0.13
Digital Concepts	0.92 *	0.96 *	0.04	1.24 *	1.36 *	0.12
Self-Efficacy						
Self-Efficacy	0.59 *	0.68 *	0.09	1.03 *	0.91 *	-0.12

* Statistically significant, $p < .05$.