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Abstract:

This study examined the feasibility of administering GED Tests using a computer based testing system with embedded accessibility tools and the impact on test scores and test-taker experience when GED Tests are transitioned from paper to computer. Nineteen test centers across five states successfully installed the computer based testing program, followed the research protocol, and transmitted testing data with minimal issues, providing evidence of the feasibility of administering GED Tests on computer. Two hundred and sixteen GED candidates participated in the research by completing two GED mathematics practice test forms and a survey. Participants completed the first form on paper and were randomly assigned to take the second form on computer or paper. The survey asked students to report demographic information, information about their use of computers, and their preference for using a computer to take tests. Regression analyses showed that participants were neither advantaged nor disadvantaged by taking the GED Mathematics Test on computer. This finding also holds true after accounting for student's reported computer use and preference for taking tests on computer.

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Examining the Feasibility and Effect of Transitioning GED Tests to Computer

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Background/Purpose

GED® Tests provide a way for adults who did not finish high school to certify their high school-level skills and knowledge. To receive a GED credential, candidates must pass the GED Tests. The GED Tests cover each of the following five content areas: Language Arts (Reading and Language Arts), Writing, Mathematics, Science, and Social Studies. The American Council on Education, through GED Testing Service, develops the GED Tests and establishes minimum passing scores. Jurisdictions (including all U.S. states) manage all test administration procedures including ordering test materials, administering the tests, having the tests scored, and reporting results to candidates. To this end, jurisdictions lease tests from the GED Testing Service annually.

As is the case with many large-scale test developers, GED® Testing Service has considered transitioning GED Tests from paper to computer (George-Ezzelle & Hsu, 2006). Education Week's 2009 *Technology Counts* reported that 26 states and the District of Columbia are planning to administer some form of computer-based state exams in 2008–2009 (Editors, 2009). The Graduate Management Achievement Test (GMAT) has been administered via computers since 1997 and the Graduate Record Examination (GRE) has been administered by computer since 1993. Computer-based test administration has the potential to save time and money, speed up results reporting and in the case of the GED Tests, make testing more accessible and make more time slots available for testing. Candidates generally prefer the option to test on the computer if available; in a 2006 candidate survey, more than two-thirds of candidates

would have preferred taking the GED Tests on computer (George-Ezzelle & Hsu, 2006). In a project outside of the scope of this article, GED Testing Service® is piloting computer-based testing in eleven U.S. states during summer 2010. Results of the pilot will inform future decisions about the direction of computer-based testing.

The GED test-taker population differs from the GRE, GMAT, and K–12 student populations. An estimated 40% of students who do not finish high school have special needs (Lohman, Lyons & Dunham, 2008); adults with learning disabilities are often overrepresented among dropouts (Mellard & Patterson, 2008). Many who decide to take the GED Tests may require specialized support in order to access test content. Without appropriate access to test items, test-takers are placed at a severe disadvantage in terms of demonstrating their knowledge and skills (George-Ezzelle & Skaggs, 2004). For paper-based test administrations, access to test content is typically provided through accommodations (George-Ezzelle & Skaggs, 2004; Hsu & George-Ezzelle, 2008). GED Tests candidates with disabilities are required to apply for accommodations and receive jurisdictional GED Administrator approval before receiving accommodations (GED Testing Service, 2008).

The types of test accommodations provided to eligible test-takers can vary widely and include reading aloud test items, increasing the font size or color contrast, providing extended time or a private space for test-taking, use of a calculator, allowing test-takers to produce written responses on computer for a paper-based test or on paper for a computer-based test, etc. (George-Ezzelle & Skaggs, 2004; Hsu & George-Ezzelle, 2008; Lohman, Lyons & Dunham, 2008). Of the five content areas tested by the GED, Lohman, Lyons, and Dunham (2008) found that mathematics was frequently most challenging for GED candidates with disabilities. Extended time and use of a calculator were also identified as the type of accommodation more frequently requested.

Like all educational tests, evidence of validity is required when eligible candidates use accommodations to take the GED Tests (George-Ezzelle & Skaggs, 2004). Unfortunately, the fidelity with which test accommodations are provided to test-takers varies widely. One study that examined the quality with which read aloud accommodations were provided to students identified several problems with this type of accommodation, including: a) the quality of the readers varies widely; b) readers occasionally mispronounce or misread words; c) readers provide intentional as well as unintentional hints to the correct answer; and d) test-takers are sometimes reluctant to ask proctors to re-read parts of an item. In other words, students are provided with a read aloud accommodation, but the accommodation itself is not delivered in a standardized or equitable manner,

and likely does not provide students with an appropriate opportunity to demonstrate their achievement (Landau, Russell, Gourgey, Erin, and Cowan, 2003).

Computer-based test delivery has the potential to overcome many of the challenges to providing high-quality accommodations in an equitable manner across test centers. By providing computer-based test accommodations a testing program can ensure that accommodations such as read aloud and signing are delivered in a standardized manner, free of mispronunciations and unintentional clues. By allowing content presented on computer to be resized and/or be presented with alternate color combinations/contrast levels, a testing program can also avoid additional expenses while assuring that these access tools are available to all test takers who require them on the day of testing.

The research described in this article focuses on the feasibility and effect of transitioning GED Tests from paper to computer, using a universally designed computer-based test system with embedded access tools. More specifically, the following three research questions were the focus of this study:

1. Is it feasible to administer GED Tests in a computer-based environment for test-takers who require accommodations and for those who do not require accommodations?

2. What is the impact on test scores and test-taker experience when a GED Mathematics Test is moved from paper to computer?

3. What is the impact on test scores and test-taker experience when a GED Mathematics Test is moved from paper to computer with embedded accessibility tools?

Testing System

NimbleTools, a universally designed test delivery system with embedded accessibility and accommodation tools, was the computer-based testing system used in this research on GED testing. The tools available to candidates during GED testing were flexibly adjusted based on the candidate's needs. For candidates who did not require a test accommodation, NimbleTools delivered the GED Mathematics Test using a standard computer-based test delivery interface. For candidates who needed a given accommodation or set of accommodations, a test proctor settings tool was used to customize the tools available for each candidate. As the candidate took a test, s/he was able to use available tools as needed. This flexibility allows testing programs to customize the delivery interface to meet the

specific needs of each candidate and for the candidate to then use specific tools as needed for each item on the test. In addition, NimbleTools collected information about the tools used for each item, which provides testing programs with more accurate data on the use of accommodations during testing.

In its current form, NimbleTools includes 18 accessibility and accommodation features. For this research, the following tools were available to candidates eligible for accommodations:

- Read aloud of text with human reader
- Magnification of text and images for candidates with moderate visual impairments
- Magnification of text and images for candidates with low vision
- Masking of test items
- Masking of answers
- Auditory Calming
- Reverse contrast with selection of contrast color
- Color overlays with selection of overlay color
- Talking Calculator
- Talking formula sheets

Figure 1 (next page) displays a screen shot of a practice GED Mathematics Test item in NimbleTools:

Figure 1:   **Screen Shot of a Practice GED Mathematics Test item in NimbleTools**
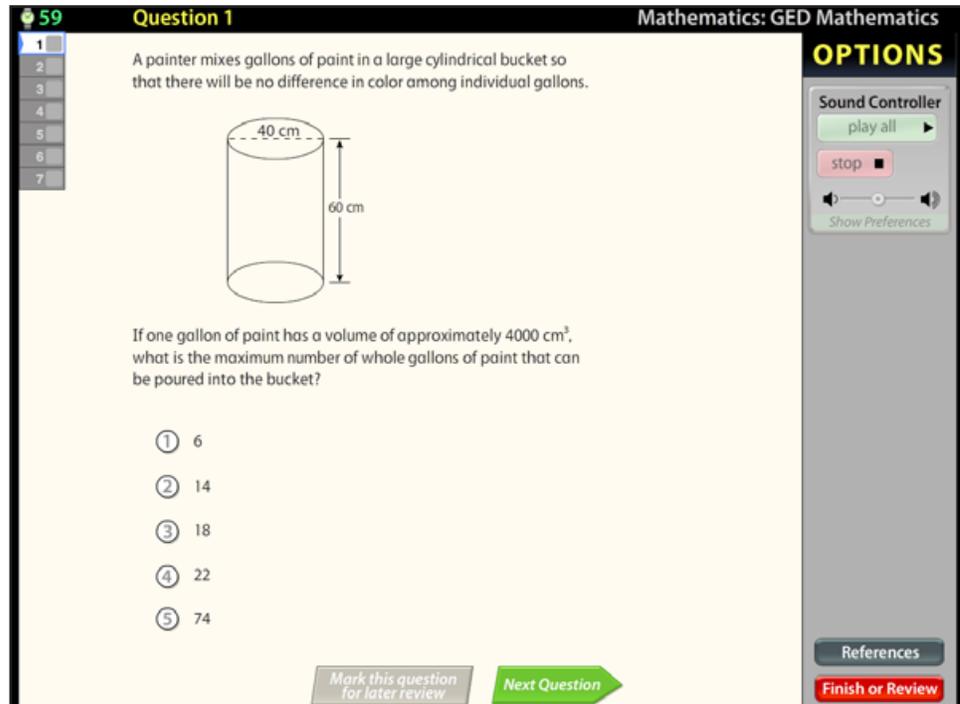
Each test center participating in the research described in this article was mailed a CD containing the NimbleTools application and technical instructions explaining how to install and launch the research test form. All participant item answers and accommodation tool usage information was transmitted from test center computers to Nimble Assessment servers via the Internet.

Research Design

In preparation for the GED Tests, test centers and adult education programs frequently offer Official GED Practice Tests (OPT) to candidates in order to gauge their readiness to pass the GED Tests; in two of the participating states, Louisiana and Wyoming, OPT was required prior to GED testing for candidates under the age of 19 and 18, respectively (GED Testing Service, 2010). For this research, two OPT mathematics test forms were used to implement a repeated measures design. For this design, test-takers were randomly assigned to groups and were asked to perform both tests under the conditions listed in Table 1. To assist in random assignment, participating test centers were mailed two lists of test-taker identification numbers and examiners were instructed to assign id numbers from the first list for candidates not needing accommodations and to assign id numbers from the second list for candidates requiring accommodations.

Table 1:   **Test Administration Group Conditions**

		Form 1	Form 2
Test-takers Requiring Accommodations	Group 1	Paper with accommodations	Paper with accommodations
	Group 2	Paper with accommodations	Computer with accessibility tools
Test-takers Requiring Accommodations	Group 1	Paper without accommodations	Paper without accommodations
	Group 2	Paper without accommodations	Computer without accessibility tools

The following research administration protocol was employed:

1. Candidates were provided a short tutorial that demonstrated how to use the standard NimbleTools interface.

2. Candidates were provided orientation files that demonstrated how to use the available accessibility tools.

3. Candidates were provided a 7-item practice mathematics test to become accustomed to using NimbleTools.

4. All candidates completed Form 1 on paper.

5. Candidates randomly assigned to Group 1 completed Form 2 on paper. Candidates randomly assigned to Group 2 completed Form 2 on computer.

6. Candidates completed a paper-based 31-item survey.

Test centers were asked to provide standard paper-based accommodations to participants who would normally receive accommodations for a GED Test for Form 1 and for Group 1 participants for Form 2. For participants assigned to Group 2 and requiring accommodations, NimbleTools allowed participants to be assigned to the tools that are appropriate for them to use during testing while taking Form 2.

After participants completed the paper-based test forms, examiners were asked to score the paper-based tests in order to provide performance feedback to candidates. The computer-based tests were scored automatically by Nimble Assessment research staff and reports were provided to test centers summarizing each participant's performance at the item level. Test centers then mailed paper-based answer forms and completed surveys to the Nimble Assessment offices for analysis.

Instruments

Each of the two test forms used in this research contained 25 GED mathematics practice items, consisting of 20 multiple-choice items and 5 short answer/grid-in items. The test forms were previously equated and therefore approximately equivalent in terms of difficulty. For each Form 2 item, a read aloud script was developed. The scripts detailed how the test content, formulas, charts and figures were to be read aloud for candidates assigned to the read aloud accommodation for Form 2. All scripts were reviewed and approved by the GED Test Development Director. Once scripts were approved, voice recordings were created. All items, voice recordings, and associated graphic files were placed into NimbleTools and were prepared for delivery.

The 25-item OPT forms were designed to allow calculator use for the first 13 items, but not allow the use of a calculator for the last 12 items. Examiners were asked to allow participants to use the standard Casio fx-260 calculator for the first section of the test form (items 1–13) and asked participants to return the calculator after completing the first section. Candidates who were taking Form 2 using NimbleTools were allowed to use the embedded calculator (or the Casio fx-260 calculator) for section 1. The NimbleTools embedded calculator was disabled for section 2 (items 14-25).

The paper-based survey consisted of three sections: demographic and educational background items, computer-use items, and NimbleTools items (taken only by Group 2 candidates). Computer-use items were asked to allow analyses of the potential impact of computer use and comfort level on the test scores of candidates assigned to take Form 2 on computer. Please refer to Appendix 1 (pages 27–32) to see detailed survey items.

Data Collection

During a July 2009 GED Administrators conference, the GED Partner Outreach Director began to recruit state-level GED Administrators to participate in this research. In succeeding months a final roster of five participating states was developed. State GED Administrators then identified and worked with interested examiners in test centers. Participants were offered free administration and scoring of the two mathematics OPT test forms and a $5 payment per test-taker for participating in the research.

Data were collected between October 2009 and February 2010. As displayed in Table 2, 219 candidates from 19 test centers and 5 states participated in the research. The number of participants per test center ranged from 3 to 38.

Table 2:   **Number of Test Centers and Participants**

State	Number of Centers	Number of Participants
Louisiana	5	61
Missouri	2	20
Nebraska	3	15
Virginia	4	90
Wyoming	5	30
Total	**19**	**216**

Table 3 (next page) summarizes demographic information about study participants, who were generally representative of candidates testing in the five states during 2009. Specifically, Table 3 indicates that 53% of participants were male and 47% female; the study oversampled females compared to 2009 gender breakout in the same five states. Black/African American and White represent the most common reported ethnicity at 39% and 47% respectively; African-American candidates were oversampled compared to the 2009 proportions for the same five states. Hispanic, American Indian/Alaskan Native, and Asian complete the ethnicities reported at 9%, 3%, and 2% respectively. The most commonly reported age range of participants was 16–19 years, accounting for 42% of responses. The spread of participant age in this study is generally similar to that of GED test-takers at the national level, with a few exceptions; the study oversampled candidates 16-19 and over 30 years of age. Finally, 85% of participants speak only English at home, with 13% speaking English and at least one other language and 2% speaking only a language other than English at home.

Table 3:   **Demographics of Participants**

Gender (*n*=196)	Percentage of Participants
Male	53%
Female	47%
Ethnicity (*n*=182)	**Percentage of Participants**
American Indian/Alaskan Native	3%
Asian	2%
Hispanic	9%
Black/African American	39%
White	47%
Age (*n*=192)	**Percentage of Participants**
16 – 19	42%
20 – 24	17%
25 – 29	10%
30 – 49	23%
50 or older	8%
Language Spoken at Home (*n*=193)	**Percentage of Participants**
English Only	85%
English and at least one other language	13%
Only language(s) other than English	2%

Table 4 (next page) summarizes study participants' reported prior education, current employment status, and amount of time spent on GED preparation. Most participants reported finishing some level of high school, with 10% reporting that they did not attend high school and 9% reporting that they completed 12th grade. When asked about employment status, 34% reported they were employed either full time or part time. Fifty one percent reported that they were not employed and looking for work, while 14% reported that they were not employed and not looking for work. When asked to report the number of hours of GED preparation that they had completed through instruction, only 9% reported that they had not completed any test preparation through instruction, 44% reported that they had completed between 1 and 20 hours, 31% reported that they had

completed between 21 and 100 hours, and 16% reported that they had completed more than 100 hours of test preparation through instruction.

Table 4:   **Education, Employment, and Test Preparation of Participants**

Last Year of High School Completed (*n*=189)	Percentage of Participants
Did not attend high school	10%
9th grade	23%
10th grade	27%
11th grade	31%
12th grade	9%
Current Employment Status (*n*=192)	**Percentage of Participants**
Employed full time	19%
Employed part time	15%
Not employed (looking for work)	51%
Not employed (retired)	1%
Not employed (not looking for work)	14%
Hours of GED Test Prep through Instruction (*n*=189)	**Percentage of Participants**
0 hours	9%
1 to 20 hours	44%
21 to 100 hours	31%
More than 100 hours	16%

Two survey items asked participants to report the amount of time that they spend using a computer on a typical day. Table 5 (next page) shows that 23% of participants reported spending no time using a computer at home and 50% reported spending no time outside of home on a computer each day. Responses to this survey item indicate that a sizable portion of the GED testing population has little or no interaction with computers on a daily basis. Candidates did not differ significantly in reported computer use, either at home or outside the home, by age, gender, or ethnicity.

Table 5:   **Time Spent on Computer**

Time spent on computer daily	At home (*n*=178)	Outside home (*n*=145)
None	23%	50%
15 minutes or less	11%	14%
15 – 60 minutes	23%	18%
An hour or two	21%	10%
Over two hours	22%	8%

Participants were asked to report their computer skills according to four descriptions. Forty-eight percent of participants reported that they were either just getting started or knew a little bit about using computers, while 52% of participants described themselves as being experienced computer users or having advanced computer skills.

Participants were also asked to report how long they have had a computer. Fifteen percent reported that they do not have a computer, while 41% reported that they have had a computer for as long as they can remember (Table 6, next page). When asked if they had previously used a computer to take a standardized test, 71% of participants reported that they had not used a computer to take a standardized test. Again, responses to these items show that some portion of the GED testing population has little experience using computers and that the majority of candidates have not used a computer for testing.

Table 6:   **Computer Use of Participants**

Computer Skills (*n*=180)	Percentage of Participants
Just getting started	10%
Know a little bit about using computers	38%
Am an experienced computer user	40%
Have advanced computer skills	12%
How long have you had a computer? (*n*=183)	**Percentage of Participants**
Do not have one	15%
Less than one year	9%
A year or two	16%
Three or four years	19%
As long as I can remember	41%
Have you previously used a computer for standardized test? (*n*=182)	**Percentage of Participants**
Yes	29%
No	71%

Feasibility

The first research question of this study focused on the feasibility of administering GED Tests in a computer-based environment. Evidence was collected by logging issues related to: 1) installation of NimbleTools; 2) transmission of data from test centers to Nimble Assessment servers; and 3) logistical or technical issues in administering Form 2 on computer. Data were collected by logging phone calls to the help desk phone number and emails to the email support address. Table 7 (next page) summarizes the calls and emails received during research administration.

Table 7:   **Summary of Support Calls**

Issue	Number of Calls/Emails
Research Design Question (assignment of ids, recruiting, where to send materials, etc)	10
System Issue Internal to Test Center	7
Login Question	6
Answer Recording Verification	5
Where to find answer key	5
Where to obtain score report	3
How to verify that login process works	1
Needed authorization to install software	1
Firewall Issue	1
Total	**41**

Table 7 shows that the most frequent issue logged related to the research design. Questions ranged from how to assign ids to participants, how to recruit candidates, how to return materials, how to receive payment of $5 per test participant, etc. None of these issues had an impact on the research administration.

The next most frequently reported issue related to seven calls from two test centers that had difficulty launching NimbleTools after installation. Both test centers independently determined that the issues were related to internal network configurations. After involving IT test center staff, the test centers were able to resolve issues on their own and successfully have candidates participate in the research.

The next five most frequently reported issues (login question, answer recording verification, where to find answer key, where to obtain score report, and how to verify that login process works) are all non-technical issues that typically arise in research studies involving new technology. Answer recording verification and verifying that the login process works are both issues of test administrators not being comfortable with online transmission of data. Examiners wanted to ensure that candidate answers were being saved online as candidates used NimbleTools. In all cases the candidate data were correctly saved.

Lastly, there was one instance of an examiner not having authorization to install NimbleTools, and there was one instance of a firewall issue

preventing the test center from accessing Nimble Assessment's servers. Again, both issues were resolved by test center staff, and candidates were able to successfully participate in the research.

All 19 test centers that chose to participate in this study were able to install NimbleTools, administer the online test form, and transmit answer information to Nimble Assessment's servers. The above table of logged calls and emails shows that although a small number of technical issues arose in test centers, they were all resolved by internal IT staff. While this study is small in scale and involved self-selected test centers, it provides evidence of the feasibility of administering GED Tests online in test centers.

Impact on Test Scores

The second research question focused on the impact on test scores and test-taker experience when a GED Mathematics Test is moved from paper to computer. Twenty of the 216 participants did not finish one of the two test forms. The data for these 20 candidates were not used in the analyses, reducing the sample size to 196. Table 8 summarizes group performance on the two test forms.

Table 8: **Descriptive Statistics of Form 1 and Form 2 Performance**

	N	Mean	Std Dev
Form 1			
Group 1 (paper)	94	10.99	4.2
Group 2 (paper)	102	12.64	4.5
Form 2			
Group 1 (paper)	94	10.60	4.3
Group 2 (computer)	102	11.20	5.0

The mean scores on Form 1 show that Group 2 performed 1.65 points higher on Form 1 than group 1. On Form 2 Group 2 performed 0.60 points higher than group 1. Overall differences in performance between groups on both forms was small. Examiner records indicated that while individual test-takers received the same length of time to take the test forms, different test centers may have permitted different time lengths for their candidates to test.

Modal Regression

In order to estimate the impact of transitioning GED Tests to computer, a regression model was created using Form 1 performance and Form 2 mode (paper or computer) to predict Form 2 performance. The mode variable was coded as 0 for candidates assigned to paper (group 1) and 1 for candidates assigned to computer (group 2). As seen in Table 9, the regression model accounted for 48.0% of the variance in Form 2 performance.

Table 9:   **Regression Model for Mode (Paper or Computer) and Form 1 Performance Predicting Form 2 Performance**

Variable	Coefficient	Standard Error	Beta	T ratio	Significance
Intercept	2.381	0.711		3.348	0.001
Mode	−0.632	0.497	−0.067	−1.271	0.205
Form 1	0.748	0.056	0.702	13.297	< 0.001

Note. R Square = 0.480

The coefficient for mode was not statistically significant (p=.205). This regression analysis shows that after taking into account Form 1 performance, there was no statistically significant difference in performance on Form 2 between candidates assigned to computer when compared to performance of candidates assigned to paper. Candidates in either group would be expected to perform about the same on either test form, whether they tested on paper or on computer.

Computer Use and Modal Preference Scaled Scores

As described in the research design section, several survey items asked participants to report information about their use of computers and their preference for using computers versus paper when taking a standardized test. Although the overall regression analysis reported no statistically significant modal effect, examining differences in performance on Form 2 while taking into account participants' reported computer use and preferences could show that candidates with little computer experience or with a preference to take tests on paper are disadvantaged by computer-based tests. To examine this issue, a principal component analysis was conducted on groups of survey items to determine the extent to which the items could be grouped together to form one score representing com-

puter use and one score representing computer preference. When items were found to be uni-dimensional, computer use and computer preference scaled scores were created for each candidate.

Computer Use Scale

The following six survey items were used in a principal component factor analysis to examine whether a single computer use scaled score could be created:

1. On a typical day how much time do you spend using a computer at home? a) none b) 15 minutes or less c) 15 to 60 minutes d) an hour or two e) over two hours

2. On a typical day how much time do you spend using a computer away from home? a) none b) 15 minutes or less c) 15 to 60 minutes d) an hour or two e) over two hours

3. Which statement below describes your personal use of computers? a) I never use a computer b) When I use a computer, I am usually afraid it won't work properly or I might break it c) I use a computer on my own, but sometimes have difficulty figuring out how to complete an unfamiliar task d) I use a computer with confidence and can figure out how to do just about anything I need to do

4. How would you describe your computer skills? a) just getting started b) know a little bit about using computers c) am an experienced computer user d) have advanced computer skills

5. How long have you had a computer? a) do not have one b) less than one year c) a year or two d) three or four years e) as long as I can remember

6. I have previously used a computer for a standardized test (such as a state assessment, professional exam, etc). a) yes, b) no

The principal component analysis yielded a two-factor solution, with factor one accounting for 42% of the variance and factor two accounting for an additional 19% of the variance. The first factor consisted of the first five items presented above. The item asking candidates if they had previously used a computer for a standardized test was the only item that heavily loaded on the second factor. A principal component factor analysis was then run excluding the sixth survey item, yielding a one-factor solution that accounts for 50% of the variance and had an alpha reliability of 0.70. Factor loadings ranged from .63 - .81. This one factor solution was used to create a scaled score representing candidates' computer use.

Computer Preference Scale

The following two survey items were used in a principal component factor analysis to examine whether a single computer preference scaled score could be created:

1. I would prefer using a computer to take a GED Test rather than using paper and pencil. a) strongly agree b) agree c) disagree d) strongly disagree

2. I want to use NimbleTools to take tests in the future. a) strongly agree b) agree c) disagree d) strongly disagree

The principal component analysis yielded a one-factor solution accounting for 83.5% of the variance, with an alpha reliability of 0.80. This one-factor solution was used to create a scaled score representing candidates' computer or paper preference.

Computer Use and Preference Regression

A regression analysis was performed to predict Form 2 performance after controlling for Form 1 performance and differences in computer use and computer preference. Because this analysis specifically focuses on the impact of prior computer use and preference on computer based test scores, only those candidates assigned to take Form 2 on the computer were included. As seen in Table 10, the regression model accounted for 45.2% of the variance in Form 2 performance.

Table 10: **Regression Model for Computer Use, Computer Preference and Form 1 Performance Predicting Form 2 Performance**

Variable	Coefficient	Standard Error	Beta	T ratio	Significance
Intercept	3.003	2.001		1.500	0.138
Computer Use	0.352	0.458	0.065	0.768	0.445
Computer Preference	0.247	0.423	0.051	0.585	0.561
Form 1	0.706	0.092	0.656	7.703	< 0.001

Note. R Square = 0.452

The coefficients for computer use and computer preference were not statistically significant (p=0.445 and p=0.561 respectively). This regression analysis shows that computer use and computer preference do not contribute to differences in candidate test performance on Form 2 after

adjusting for Form 1 performance. Candidates did not differ statistically by age, gender, or ethnicity as to whether it was easy for them to take the test on the computer.

Impact on Candidate Experience

An important factor to consider in transitioning GED Tests from paper to computer is the impact on candidates' test-taking experience. All study participants were asked a survey question about their preference for taking GED Tests on computer rather than paper. Sixty-one percent of participants agreed or strongly agreed that they would prefer to use a computer to take the GED Tests. Candidates did not differ significantly in preference by age, gender, or ethnicity.

Table 11:   **Computer Test Preference (Both Groups)**

Prefer using a computer to take a GED Test rather than paper?	Percentage of Participants
Strongly agree	24%
Agree	37%
Disagree	28%
Strongly disagree	11%
Total	41

Candidates who were randomly assigned to group 2 were asked additional questions about their experience taking Form 2 on computer. When asked if they would prefer to use NimbleTools to take tests in the future, 61% agreed or strongly agreed that they would prefer to use NimbleTools versus paper, as shown in Table 11. This percentage is identical to the percentage of all participants who agreed or strongly agreed that they would like to use a computer to take a GED Test. One inference that can be made from this comparison is that taking Form 2 on computer did not influence candidates' desire to take future tests on computer.

Table 12:   **Computer Test Preference and Experience (Group 2 only)**

I want to use NimbleTools to take test in future	Percentage of Participants
Strongly agree	20%
Agree	41%
Disagree	29%
Strongly disagree	10%
It was easy taking test on computer	**Percentage of Participants**
Strongly agree	24%
Agree	51%
Disagree	23%
Strongly disagree	2%

Candidates assigned to Group 2 were also asked to respond to the prompt "It was easy taking the test on computer." Seventy-five percent of participants who were administered Form 2 on computer either agreed or strongly agreed that it was easy to take the test on computer and only 2% of participants strongly disagreed that it was easy taking the test on computer. It is encouraging to note that although 39% of participants would prefer to take GED Tests on paper, only 25% of those who were administered Form 2 on computer reportedly found it difficult to take the test on computer.

Impact on Test Scores for Candidates using Accessibility Tools

The third research question focused on the impact of transitioning GED Tests to the computer for candidates using accessibility or accommodation tools. Of the 216 participating candidates, 22 used accessibility tools and finished both forms, limiting the evidence that could be collected to answer this research question.

Table 13:   **Descriptive Statistics of Form 1 and Form 2 Performance for Candidates Using Accessibility Tools**

	N	Mean	Std Dev
Form 1			
Group 1 (paper)	13	9.46	4.1
Group 2 (paper)	9	10.56	3.6
Form 2			
Group 1 (paper)	13	8.69	3.0
Group 2 (computer)	9	9.56	3.0

The mean scores on Form 1 show that Group 2 performed 1.10 points higher than Group 1. Form 2 performance shows that candidates assigned to computer performed 0.87 points higher than candidates assigned to paper. The differences in scores between the two accommodated groups were not statistically significant across testing modes. Candidates requiring accommodations performed about the same on either form and in either mode.

Summary of Results

1. Although narrow in scope and relatively small in size, this research study provides evidence that administering GED Tests by computer for candidates needing accessibility tools and for candidates not needing accessibility tools is feasible. Nimble Assessment staff successfully worked with GED Testing Service test development, research and partner outreach staff to create read aloud scripts and reproduce a Mathematics Test form in a computer environment. Nineteen test centers in five states successfully installed NimbleTools, administered the research to candidates assigned to take Form 2 on computer, and transmitted data to Nimble Assessment's servers.

2. Candidates were generally representative of 2009 GED Tests candidates in the five participating states. They did not differ significantly in computer use, computer preference, or perception of ease of computer use by age, gender, or ethnicity. A regression analysis that used Form 1 and mode of administration (paper or computer) to predict Form 2 performance provided evidence that candidates are neither advantaged nor disadvantaged by moving paper-based GED Tests to computer.

3. A regression analysis that used Form 1 performance, computer use, and computer preference variables to predict Form 2 performance provided evidence that candidates are neither advantaged nor disadvantaged by prior computer use and preference when GED Tests are transitioned from paper to computer.

4. The sample of participants using accessibility tools was small (*n*=22), but also shows that candidates eligible for accommodations were neither advantaged nor disadvantaged when the OPT was administered on computer.

5. Although a significant portion of the research sample preferred to take GED Tests on paper (39%), 75% of participants that were assigned to take Form 2 on computer reported that it was easy to take the test on computer.

Discussion

At a qualitative level, this study yielded several valuable results. It demonstrated that test centers could successfully install and administer computer-based tests for a small number of candidates—and offered insights into the type of challenges they might face in getting started with computer-based testing and how those challenges could be resolved.

Knowing that candidates in the study were representative of the states in which the study occurred is particularly useful to states with similar numbers of candidates, that is, those testing between 2,000 and 20,000 GED Tests candidates annually. This evidence, while incomplete for all test centers in the GED testing program, is also promising for individual test centers in those states that serve comparable numbers of candidates. Future research could expand this type of computer feasibility and effect research to larger test centers and to additional states.

In addition, use of NimbleTools offered GED Tests candidates with disabilities who were eligible for accommodations the potential to access computer-based testing as equitably as candidates who did not require accommodations. Candidates scored about the same on both forms of the Mathematics OPT, even after controlling for test mode (computer or paper), for frequency of computer use, or for preference of computer- or paper-based testing. This finding, though on a small scale, is similar to that of George-Ezzelle & Skaggs (2004). Especially for the challenging Mathematics Test (Lohman, Lyons & Dunham, 2008), it may be reassuring to candidates with disabilities that they would not need to be excluded from computer-based testing opportunities simply because they were eligible for accommodations. Whether they were new to computers or experienced computer users, whether they preferred taking the test on

the computer or on paper, it is critical to ensure that an avenue to computer-based testing could be open to all candidates, regardless of disabilities status. These results will add to the evidence base collected in the GED Testing Service computer-based testing pilot from summer 2010.

A concern at the start of the study was whether candidates might differ demographically in perception of ease of use or preference for computer versus paper testing. They did not; knowing that male and female test-takers of different ages and ethnic backgrounds tended to share a preference for or against computer-based testing suggests that these preferences may be common to all candidates, at least in smaller test centers. Candidates' preference for taking the test on computer, at 61%, is similar to George-Ezzelle & Hsu's (2006) finding of 66%, and it is equally promising that candidates with and without disabilities shared similar preferences. The fact that three-fourths of candidates in the study found computer-based testing easy to use could be encouraging to future computer-based test-takers. Future qualitative research should investigate why approximately 40% of test-takers preferred paper-based testing and what implicit barriers might be associated with that preference.

Other suggestions for future research could include examining additional content area tests, to see how candidates with and without disabilities would perform in reading, social studies, science, and writing. Candidates in both statuses could also be interviewed on their computer test-taking experience, to qualitatively understand what they liked and disliked about the experience, what challenged them, and their perceptions of the test items. A larger study of candidates with disabilities who are eligible for accommodations would add to the evidence base. Knowing which accessibility tools were most often used and the effects of extended time or private testing space (George-Ezzelle & Skaggs, 2004) would also be beneficial.

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Appendix 1

GED Test-taker Survey

Instructions:

Please place an X next to the letter of the appropriate response. This survey is double sided please answer items on both sides. Thank you!

1. **Gender**
    - Male
    - Female

2. **Ethnicity (Select all that apply)**
    - American Indian/Alaskan Native
    - Asian
    - Pacific Islander/Native Hawaiian
    - Hispanic
    - Black/African American
    - White

3. **What language(s) do you speak at home?**
    - English only
    - English and at least one other language
    - Only language(s) other than English

4. **What is your age?**
    - 16–19 years old
    - 20–24 years old
    - 25–29 years old
    - 30–49 years old
    - 50 years or older

5. **What is the last year of high school that you completed?**
    - Did not attend high school
    - 9th Grade
    - 10th Grade
    - 11th Grade
    - 12th Grade

6. **What is your current employment status?**
    - Employed full time
    - Employed part time
    - Not employed (and looking for work)
    - Not employed (retired)
    - Not employed (not looking for work nor retired)

7.   How many hours did you prepare for the GED Test through instruction?

- ○ 0 hours
- ○ 1 to 20 hours
- ○ 21 to 100 hours
- ○ More than 100 hours

Please only answer the inext three tems if you are requesting accommodations on the GED Test:

8.   If you request accommodations on the GED Test, which request form would you fill out?

- ○ learning / other cognitive disabilities
- ○ emotional / mental health
- ○ attention-deficit / hyperactivity disorder
- ○ physical / chronic health disability
- ○ not sure

9.   Are you taking this test with extended time?

- ○ yes
- ○ no

10.   Are you taking this test in a private room?

- ○ yes
- ○ no

11.   Are you taking this test with a supervised break?

- ○ yes
- ○ no

Computer Use Questions

1.   On a typical day how much time do you spend using a computer

At Home?	**At work or away from home?**
○ None	○ None
○ 15 minutes or less	○ 15 minutes or less
○ 15 to 60 minutes	○ 15 to 60 minutes
○ An hour or two	○ An hour or two
○ Over two hours	○ Over two hours

2.   **Which of the statements below best describes your personal use of computers?**
-   I never use a computer.
-   When I use a computer, I am usually afraid it won't work properly or that I might break it.
-   I use a computer on my own, but sometimes have difficulty figuring out how to complete an unfamiliar task.
-   I use a computer with confidence and can figure out how to do just about anything I need to do.

3.   **How would you best describe your computer skills?**
-   Just getting started
-   Know a little bit about using computers
-   Am an experienced computer user
-   Have advanced computer skills

4.   **How many computers, if any, do you have at home?**
-   0
-   1
-   2
-   3 or more

5.   **How long have you had a computer at home?**
-   Do not have one
-   Less than one year
-   A year or two
-   Three or four years
-   As long as I can remember

6.   **What type of Internet connection do you have at home?**
-   Do not have an internet connection at home.
-   Use a phone line to connect to the Internet at home.
-   Use a DSL or high-speed cable to connect to the Internet at home.
-   Use a wireless connection to access the Internet at home.
-   Have an internet connection at home but I don't know much about it.

7.   **I have previously used a computer for a standardized test (such as a state assessment, professional exam, etc.).**
-   yes
-   no

8.   **I would prefer using a computer to take the GED Test rather than using paper and pencil.**
   o Strongly Agree
   o Agree
   o Disagree
   o Strongly disagree

Please only answer the remaining questions if you took the second test form on the computer. Indicate the extent to which you agree or disagree with the following statements by placing an X next to the letter of the appropriate response.:

1.   **It was easy to take the test on a computer.**
   o Strongly Agree
   o Agree
   o Disagree
   o Strongly disagree

2.   **The tutorial was easy to use..**
   o Strongly Agree
   o Agree
   o Disagree
   o Strongly disagree

3.   **The tutorial helped me learn how to take a test on a computer.**
   o Strongly Agree
   o Agree
   o Disagree
   o Strongly disagree

4.   **The tutorial helped me learn how to use the read aloud, magnification, and other tools.**
   o Strongly Agree
   o Agree
   o Disagree
   o Strongly disagree
   o Did not use tools

5. **The read aloud tools were easy to use.**
- ○ Strongly Agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree
- ○ Did not use read aloud tools

6. **The read aloud tools were helpful during the test.**
- ○ Strongly Agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree
- ○ Did not use read aloud tools

7. **The magnification tools were easy to use.**
- ○ Strongly Agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree
- ○ Did not use magnification tools

8. **The magnification tools were helpful during the test.**
- ○ Strongly Agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree
- ○ Did not use magnification tools

9. **The tools helped me better access test content.**
- ○ Strongly Agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree
- ○ Did not use tools

10. **I want to use NimbleTools to take tests in the future.**
- ○ Strongly Agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree

Open-Response Items

1.   Describe any problems you had using the computer to take the test.

2.   Describe any suggestions you have for improving NimbleTools.

Thank you for your participation in this research!

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