

**Comparison of Computer-Delivered CAPT and Paper-and-Pencil CAPT**

**Report to CSDE**

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## EXECUTIVE SUMMARY

The purpose of this report is to present findings of a comparability study of paper-and-pencil (P&P) and computer-based (CB) forms of the CAPT. The study was conducted during the 2012 CAPT operational testing window. All eligible students took the operational form under standard conditions. In addition, samples of students were administered computer-based Reading, Writing, or Science tests constructed from previously administered items. Computer-based tests were taken by students on a separate day after the operational administration and with the knowledge that their performance did not count towards their CAPT score.

After equating the CB tests to the scale of the P&P tests, item difficulty parameter estimates, expected score functions, and standard error functions for the CB and P&P tests were compared in all subjects in order to assess the equivalence of the forms. Items were considered non-equivalent if the CB difficulty estimate exceeded the P&P estimate by more than 0.3.

The results of the analyses show that, overall, the computer-based and paper-and-pencil forms of the CAPT were of similar difficulty in all subject areas with only a few items showing substantial discrepancies between forms. These findings are in strong contrast to those found for the CMT, where the computer-based tests were consistently more difficult than their paper-and-pencil counterparts across grades and subjects.

These results support the conclusion that the CAPT tests could be offered in computer-based form without compromising the validity of the results, and with reasonable confidence in the comparability of the computer-based and paper-and-pencil test scores. The few items that showed substantial discrepancies in difficulty between their P&P and CB versions should not be used on computer-based forms.

## **Purpose of the Study**

With the introduction of common core assessments in 2014 under the SBAC consortium, Connecticut's state-wide assessment will move to a computer-adaptive testing environment. To investigate logistical and psychometric problems that may arise as a result of this transition and to begin to prepare schools for it, pilot computer-based (CB) administrations of the CMT and CAPT were conducted in the Spring of 2012 during the operational testing window. The goal of these administrations was to provide data for investigating whether the CB versions of the CMT and CAPT were psychometrically equivalent to the paper-and-pencil (P&P) forms so that, if so, schools could be given the option of administering the Spring 2013 tests via computer. This experience would help to prepare schools for the transition to fully computer-delivered administration.

Numerous prior studies have investigated the comparability of CB and P&P test forms in a variety of contexts. Wang and Shin (2009) provide a concise summary of the research to date. In the area of K-12 education, the research is not conclusive. Three large meta-analytic studies (Wang, Jiao, Young, Brooks, & Olson, 2007, 2008; Kingston, 2009) found no statistically significant effect of delivery mode on mathematics or reading achievement, or only small effects. However, Wang and Shin note that despite the overall consensus, the results are by no means unanimous. This inconsistency may be due to both student and technology factors in a given context. Leeson (2006), in a review of literature, identified student characteristics such as gender and ethnicity, cognitive processing (memory and comprehension), ability, and familiarity with and anxiety about computers. Given the increasing presence of computers in the lives of all students, some of these personal factors may be less influential today than even six years ago. Technology factors that may influence student performance include screen size and resolution,

font, line length, number of lines, spacing and whitespace, scrolling, and number of items per screen. The ability to review items or not may also affect performance.

The body of research to date suggests that comparability of CB and P&P test forms cannot be assumed and must be verified in any testing context. The purpose of this report is to present findings of the analysis of the CB and P&P forms of the CAPT and make recommendations regarding the future administration of the CAPT in computer-delivered form. These results will also provide valuable information for the construction of the new common core assessments

## **Design of the Study**

### **Data Collection**

All eligible students took the operational form under standard conditions in the Spring of 2012. In addition, samples of students were administered a computer-based version of the CAPT Reading, Writing, and Science tests, with each student taking only one form. The computer-based forms were constructed from previously administered CAPT items for which item statistics were available. Unlike the design of the CMT comparability study, the CB forms were not intact previously administered operational forms. Students took the computer-based test on a separate day after the operational form and with the knowledge that their performance did not count towards their CAPT score. The sampling plan was devised by Measurement Incorporated. The data collection design and sample sizes available for analysis for each subject are depicted in Figure 1.

Figure 1  
Data Collection Design for the Comparability Study

<b>Reading</b>					
		2012 CAPT P&P		CB Pilot	
		RI	RL	RI	RL
N Items:		18	1	18	1
				988	
					1524

RI: Reading for Information  
RL: Response to Literature

<b>Writing</b>						
		2012 CAPT P&P			CB Pilot	
		ER	IW1	IW2	ER	IW
N Items:		18	1	1	18	1
					788	
						1579

ER: Editing and revising  
IW: Interdisciplinary writing

<b>Science</b>				
		2012 CAPT P&P		CB Pilot
		SC_Section 1	SC_Section 2	SC
N Items:		31	34	32
				887

SC: Science

## **Analysis**

Prior to beginning the comparability analyses, the characteristics of the samples taking the CB forms were compared to those of the total student population taking the CAPT to ensure that the samples were representative.

In carrying out the comparability study, the one-parameter IRT model was fitted to the item response data using the WinSteps computer program, as is the current practice for all operational CAPT purposes. Using the operational form as an anchor, the item parameters of the computer-based form were estimated and equated to the operational form, which had previously been equated to the bank scale. Two different equating procedures were used. In the first, the operational form item parameters were held fixed during calibration, and the CB form parameters were estimated. The CB form parameters were then automatically on the bank scale. In the second procedure, a free calibration was performed on the combined operational and CB form data, and an equating coefficient computed by the difference in the mean operational form bank item parameter values and the mean free calibration operational form values. The operational form parameters were placed on the bank scale by adding the equating coefficient. The equated operational form item parameters were then examined to determine whether there were any large deviations from the bank values. Following standard equating procedures used by the CSDE and MI, if there were any differences between the bank value and the equated value of more than 0.3, the equating was repeated excluding the item with the largest discrepancy. This procedure was repeated until all discrepancies in the set of equating items were less than 0.3. Once the final equating coefficient was obtained, it was added to the CB form item parameters to adjust the mean difficulty and place the parameters on the bank scale.

The items in the CB forms had been previously administered in paper-and-pencil (P&P) form either in field tests or in operational administrations and their item parameters had been equated to the bank scale. The equated CB item parameters from the new calibration were then compared to the bank values to investigate the extent to which the CB and P&P forms were psychometrically equivalent.

To examine overall differences in the test forms, expected score functions and standard error functions were computed for each form. The expected score function gives the score that a student at a given proficiency level (on the theta scale) would be expected to receive on each form, given the item parameters for that form. These functions will reveal overall differences in difficulty between the test forms. Standard error functions show the standard error at each theta value and thus provide information about differences in the precision of measurement for the two forms.

Finally, theta estimates obtained for the same student on the 2012 P&P operational test and the CB form were compared to assess the extent to which students were performing in the same way on the two tests. High correlations would provide some evidence that the tests are measuring the same skills, but would not rule out the presence of extraneous constructs.

## Results

Distributions of gender, ethnicity, ELL status, special education status, and lunch status, along with mean CAPT scores, are provided in Table A1. As the table shows, the samples were representative of the full population both demographically and with respect to proficiency distribution.

Item parameter estimates for the fixed anchor and free calibrations were very similar, so only the results for the fixed anchor calibrations are reported here. Tables A2 through A4 in the Appendix contain the banked item parameter values and adjusted CB form item parameter values for each subject. Figures A1 through A3 provide plots of the equated CB item parameters against the P&P bank values.

Figures 2 through 4 show the discrepancies between the P&P and CB item parameters by item order and section for each subject in each grade. In contrast to the CMT, there were few large discrepancies between the P&P and CB item parameters for Reading, with no consistent pattern of differential difficulty between forms. Only three items had difficulty discrepancies of more than 0.3, with two of these being more difficult on the CB test than in paper-and-pencil form. The largest discrepancy favored the CB test. While the first few items appeared to be slightly easier on the CB test, no conclusions can be drawn with respect to item order effects because the P&P items were never administered together as a complete form.

On the Writing test, five items had difficulty discrepancies exceeding 0.3, with three of those more difficult on the CB test than in paper-and-pencil form. Two of these were substantially more difficult on the CB test (discrepancies exceeding 0.6). A similar pattern was observed on the Science test: four items had difficulty discrepancies exceeding 0.3, with two of



those substantially more difficult on the CB test than in paper-and-pencil form (discrepancies exceeding 0.6).

Omit rates were very low for all CB tests (Table A5) and did not increase for items towards the end of the test, indicating that the time limits were adequate in all subject area. Examination of the characteristics of the items with the largest discrepancies in each subject area (Tables A6 to A8) yielded no clear explanations of the difference in difficulties of the items.

Figure 2  
Discrepancy Between CAPT Computer-Based Reading Difficulty Estimates and Paper-and-Pencil Bank Values

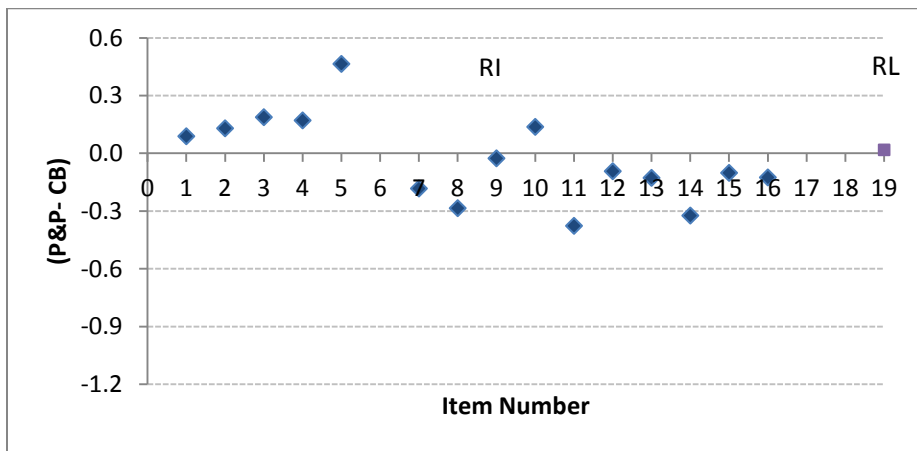


Figure 3  
Discrepancy Between CAPT Computer-Based Writing Difficulty Estimates and Paper-and-Pencil Bank Values

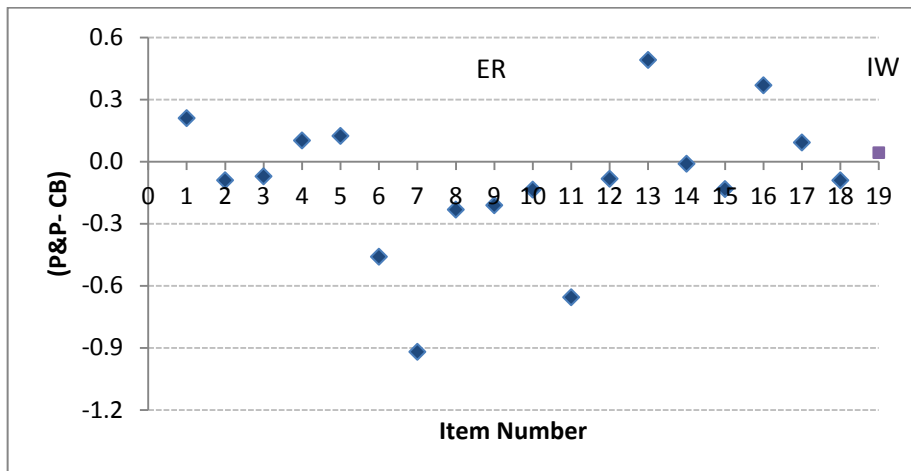
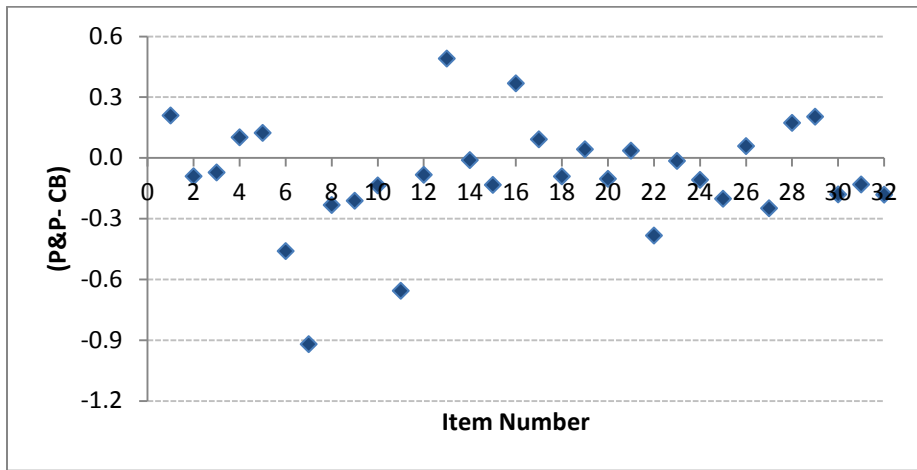


Figure 4  
 Discrepancy Between CAPT Computer-Based Science Difficulty Estimates and Paper-and-Pencil Bank Values



Expected score functions and standard error functions for the P&P and CB forms based on the equated item parameters are presented in Figures 5 to 10. As the figures show, there were only slight differences overall between the P&P and CB forms in all subject areas.

Figures A4 through A6 provide plots of theta (proficiency) estimates from the two administrations for each grade and subject. Given the short length of the Reading and Writing tests, very high correlations between theta estimates are not expected. The correlation between theta estimates for Reading was 0.70 and for Writing, 0.51. For Science, based on 32 items, the correlation between theta estimates was 0.83. A correlation this high indicates that students would generally be ranked the same way on the CB and P&P tests. Given the similarity of results between the Science test and the Reading and Writing tests with respect to difficulty discrepancies, it could reasonably be expected that similarly high correlations between theta estimates would have been obtained for Reading and Writing had these forms been longer.

Figure 5  
Expected Score Functions for CAPT Reading Using P&P and CB Equated Item Parameter Estimates

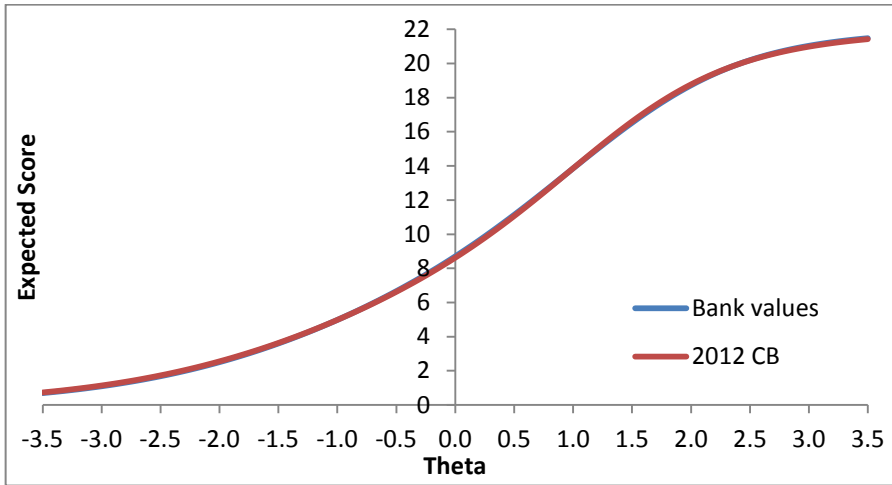


Figure 6  
Standard Error Functions for CAPT Reading Using P&P and CB Equated Item Parameter Estimates

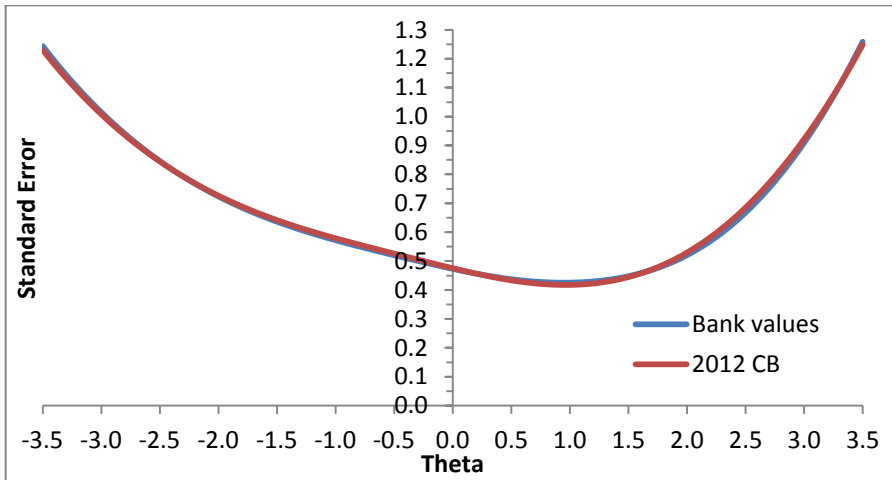


Figure 7  
Expected Score Functions for CAPT Writing (ER) Using P&P and CB Equated Item Parameter Estimates

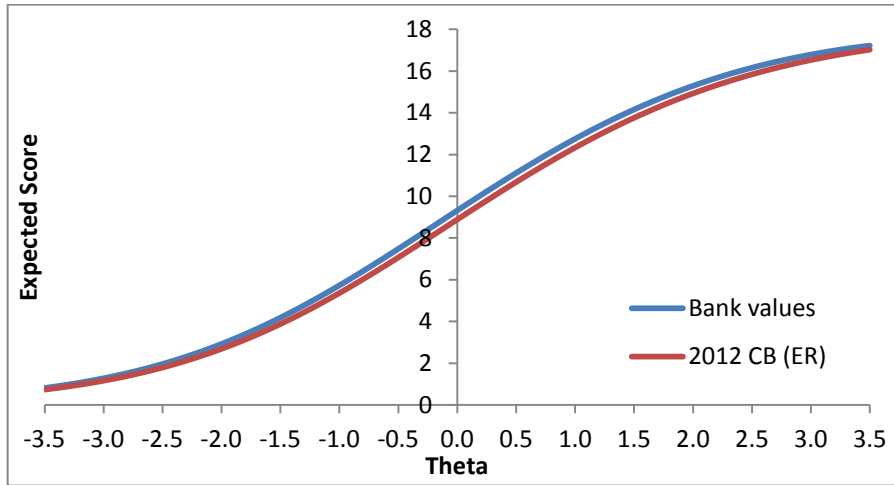


Figure 8  
Standard Error Functions for CAPT Writing (ER) Using P&P and CB Equated Item Parameter Estimates

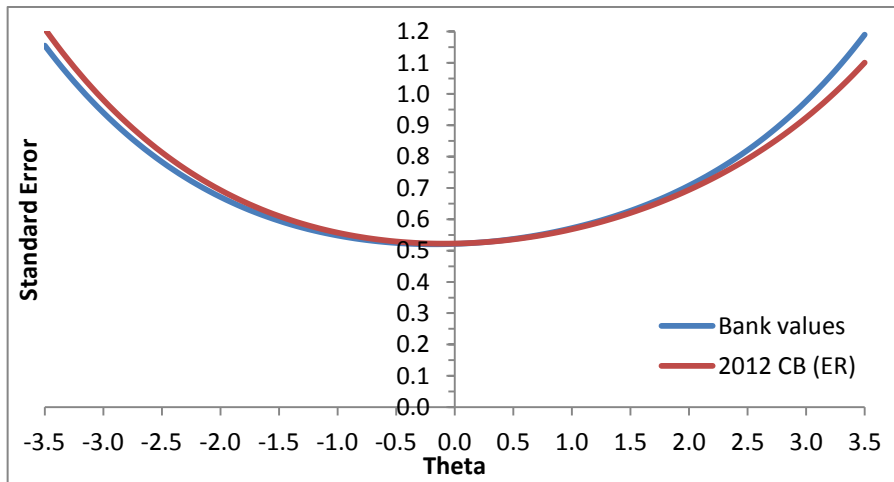


Figure 9  
Expected Score Functions for CAPT Science Using P&P and CB Equated Item Parameter Estimates

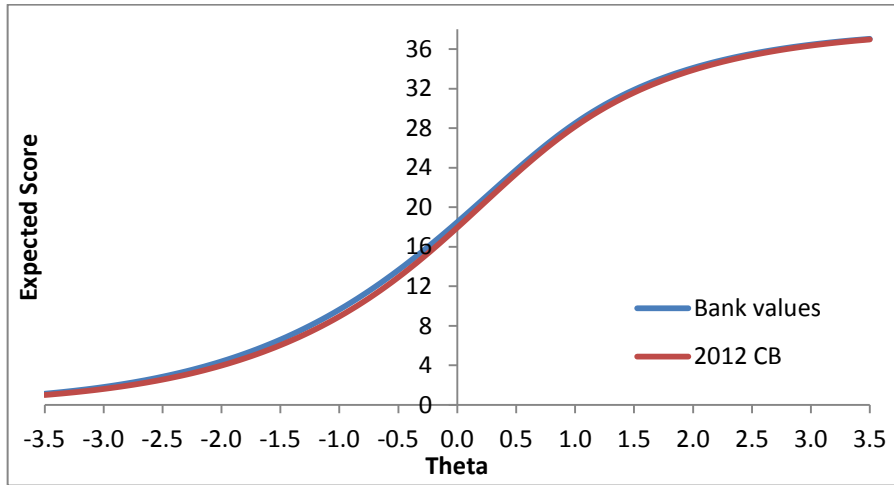
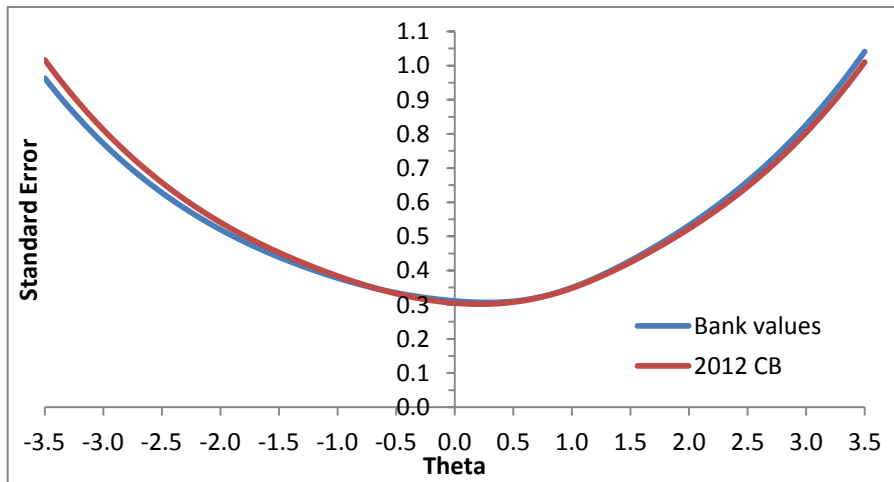


Figure 10  
Standard Error Functions for CAPT Science Using P&P and CB Equated Item Parameter Estimates



## **Summary and Recommendations**

The results of these analyses show that, overall, the computer-based and paper-and-pencil forms of the CAPT were of similar difficulty with only a few items showing substantial discrepancies between forms. These findings are in strong contrast to those found for the CMT, where the computer-based tests were consistently more difficult than their paper-and-pencil counterparts across grades and subjects.

These results support the conclusion that the CAPT tests could be offered in computer-based form without compromising the validity of the results, and with reasonable confidence in the comparability of the computer-based and paper-and-pencil test scores. The few items that showed substantial discrepancies in difficulty between their P&P and CB versions should not be used on computer-based forms.

## **APPENDIX**

Table A1  
Demographic and Performance Comparison of CAPT Population and CB Samples

Variable	Value	Reading		Writing		Science	
		Pop.	Sample	Pop.	Sample	Pop.	Sample
Gender	F	49.7	47.6	49.7	50.4	49.7	53.7
	M	50.3	52.4	50.3	49.6	50.3	46.3
Ethnicity	H	15.3	15.0	15.3	16.0	15.3	12.6
	B	12.4	11.5	12.4	13.2	12.4	8.3
	W	66.3	66.6	66.3	64.9	66.3	71.6
Lunch	Free	23.6	24.6	23.6	22.9	23.6	17.6
	Reduced	5.3	4.9	5.3	5.3	5.3	5.5
	None	71.1	70.6	71.1	71.8	71.1	76.9
ELL	ELL	3.0	2.8	3.0	2.6	3.0	2.0
	Not ELL	97.0	97.3	97.0	97.4	97.0	98.0
SPED	Enrolled	8.0	6.5	8.0	6.9	8.0	6.3
	Not Enrolled	92.0	93.5	92.0	93.1	92.0	93.7
Raw Score	Mean	24.7	26.5	37.9	38.5	46.8	48.9
	SD	7.7	7.2	9.4	8.7	14.8	13.9



Table A2  
 Bank (P&P) and Equated (CB) Item Parameter Values for CAPT Reading Form

Item	Bank Value	2012 Equated CB Value	Discrepancy
1	-0.038	-0.137	0.099
2	-0.724	-0.865	0.140
3	-1.029	-1.227	0.198
4	-0.421	-0.603	0.181
5	1.685	1.212	<b>0.474</b>
6	1.655	1.020	<b>0.635</b>
7	0.777	0.950	-0.173
8	-0.642	-0.367	-0.275
9	-1.527	-1.511	-0.015
10	-1.682	-1.831	0.148
11	1.170	1.538	<b>-0.368</b>
12	0.520	0.604	-0.083
13	0.000	0.118	-0.117
14	0.285	0.599	<b>-0.314</b>
15	-0.536	-0.445	-0.091
16	-0.455	-0.340	-0.115
17	0.882	1.385	<b>-0.503</b>
18	1.480	1.376	0.104
19	0.614	0.593	0.021

Table A3  
 Bank (P&P) and Equated (CB) Item Parameter Values for CAPT Writing Form

Item	Bank Value	2012 Equated CB Value	Discrepancy
1	-0.035	-0.046	0.011
2	1.920	2.728	<b>-0.807</b>
3	-1.343	-1.194	-0.149
4	0.371	0.311	0.060
5	-1.248	-1.378	0.130
6	1.300	1.599	-0.299
7	0.490	0.462	0.028
8	-0.650	-0.540	0.110
9	-0.630	-0.381	-0.249
10	-0.050	0.205	-0.255
11	-0.400	-0.272	-0.128
12	-0.410	-0.692	0.282
13	-1.520	-1.480	-0.040
14	-0.259	0.005	-0.263
15	-1.322	-0.574	<b>-0.748</b>
16	0.199	0.426	-0.228
17	0.831	1.018	-0.187
18	1.662	1.569	0.094
19	1.368	1.263	0.105

Table A4  
 Bank (P&P) and Equated (CB) Item Parameter Values for CAPT Science Form

Item	Bank Value	2012 Equated CB Value	Discrepancy
1	0.459	0.256	0.202
2	0.566	0.663	-0.097
3	-0.347	-0.266	-0.081
4	-0.797	-0.890	0.093
5	0.610	0.492	0.118
6	-0.812	-0.344	<b>-0.468</b>
7	-0.913	0.014	<b>-0.927</b>
8	0.667	0.905	-0.238
9	-0.749	-0.529	-0.219
10	-0.005	0.137	-0.143
11	0.135	0.797	<b>-0.661</b>
12	-0.299	-0.208	-0.091
13	0.551	0.067	<b>0.484</b>
14	-1.329	-1.309	-0.020
15	0.130	0.269	-0.140
16	0.204	-0.157	<b>0.361</b>
17	0.932	0.845	0.086
18	-0.043	0.055	-0.098
19	-0.192	-0.227	0.035
20	-0.641	-0.529	-0.111
21	-0.805	-0.832	0.028
22	-1.000	-0.609	<b>-0.391</b>
23	-0.275	-0.253	-0.022
24	0.166	0.281	-0.115
25	0.394	0.602	-0.207
26	-0.001	-0.053	0.051
27	-0.339	-0.083	-0.256
28	0.385	0.218	0.167
29	0.651	0.454	0.198
30	0.855	1.040	-0.185
31	-0.321	-0.182	-0.139
32	0.194	0.382	-0.188

Table A5  
Omit Rates on 2012 Computer-Based Items

Item	Reading (RI)	Writing (ER)	Science
1	0.00	0.00	0.01
2	0.00	0.00	0.02
3	0.00	0.00	0.01
4	0.00	0.00	0.00
5	0.02	0.00	0.00
6	0.02	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.01
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.02	0.00	0.00
12	0.02	0.00	0.00
13	0.02	0.00	0.00
14	0.02	0.00	0.00
15	0.02	0.00	0.01
16	0.03	0.00	0.00
17	0.06	0.00	0.00
18	0.06	0.00	0.00
19			0.00
20			0.00
21			0.00
22			0.00
23			0.00
24			0.01
25			0.00
26			0.01
27			0.00
28			0.00
29			0.00
30			0.00
31			0.01
32			0.01

Table A6  
 Characteristics of CAPT Reading Information Items with Largest and Smallest Discrepancies  
 Between Paper-and-Pencil and Computer-Based Item Parameters

<b>LARGEST DISCREPANCIES</b>									
Item Number	6	17	5	11	14	8	3	4	7
Section	RI	RI	RI	RI	RI	RI	RI	RI	RI
Passage	1	3	1	2	3	2	1	1	2
2010 Bank Value	1.66	0.88	1.69	1.17	0.29	-0.64	-1.03	-0.42	0.78
Adjusted CBT Value*	1.02	1.39	1.21	1.54	0.60	-0.37	-1.23	-0.60	0.95
Difference	0.64	-0.50	0.47	-0.37	-0.31	-0.27	0.20	0.18	-0.17
Item Type	OE	OE	OE	OE	MC	MC	MC	MC	MC
First item in the CB test	NO	NO	NO	NO	NO	NO	NO	NO	NO
Scrolling needed to see all answers (MC) or complete answers (OE)	YES	YES	YES	YES	NO	NO	NO	NO	NO
Correct answer visible without scrolling (MC only)									
Question visible when scrolling for answer	NO	NO	NO	NO					
<b>SMALLEST DISCREPANCIES</b>									
Item Number	10	2	13	16	18	1	15	12	9
Section	RI	RI	RI	RI	RI	RI	RI	RI	RI
Passage	2	1	3	3	3	1	3	2	2
2010 Bank Value	-1.68	-0.72	0.00	-0.46	1.48	-0.04	-0.54	0.52	-1.53
Adjusted CBT Value*	-1.83	-0.86	0.12	-0.34	1.38	-0.14	-0.44	0.60	-1.51
Difference	0.15	0.14	-0.12	-0.11	0.10	0.10	-0.09	-0.08	-0.02
Item Type	MC	MC	MC	MC	OE	MC	MC	OE	MC
First item in the CB test	NO	NO	NO	NO	NO	YES	NO	NO	NO
Scrolling needed to see all answers (MC) or complete answers (OE)	NO	NO	NO	NO	YES	NO	NO	YES	NO
Correct answer visible without scrolling (MC only)									
Question visible when scrolling for answer					NO			NO	

Table A7  
 Characteristics of CAPT Writing Editing and Revising Items with Largest and Smallest  
 Discrepancies Between Paper-and-Pencil and Computer-Based Item Parameters

<b>LARGEST DISCREPANCIES</b>									
Item Number	2	15	6	12	14	10	9	16	17
2010 Bank Value	1.92	-1.32	1.30	-0.41	-0.26	-0.05	-0.63	0.20	0.83
Adjusted CBT Value*	2.73	-0.57	1.60	-0.69	0.00	0.20	-0.38	0.43	1.02
Difference	-0.81	-0.75	-0.30	0.28	-0.26	-0.25	-0.25	-0.23	-0.19
First item in the CB test	NO	NO	NO	NO	NO	NO	NO	NO	NO
Presentation of answer changes on CB form	YES	NO	YES	NO	YES	NO	YES	YES	NO
Answer Key sentences wrapped in P&P but not in CBT	YES		YES		YES		YES	NO	
Scrolling needed to see all answers (MC only)	NO	NO	NO	NO	NO	NO	NO	YES	NO
Correct answer visible without scrolling (MC only)								YES	
Question visible when scrolling for answer								NO	

<b>SMALLEST DISCREPANCIES</b>									
Item Number	3	5	11	8	18	4	13	7	1
2010 Bank Value	-1.34	-1.25	-0.40	-0.65	1.66	0.37	-1.52	0.49	-0.04
Adjusted CBT Value*	-1.19	-1.38	-0.27	-0.54	1.57	0.31	-1.48	0.46	-0.05
Difference	-0.15	0.13	-0.13	-0.11	0.09	0.06	-0.04	0.03	0.01
First item in the CB test	NO	NO	NO	NO	NO	NO	NO	NO	YES
Presentation of answer changes on CB form	NO	NO	NO	NO	NO	YES	NO	YES	NO
Answer Key sentences wrapped in P&P but not in CBT						NO		YES	
Scrolling needed to see all answers (MC only)	NO	NO	NO	NO	NO	YES	NO	NO	NO
Correct answer visible without scrolling (MC only)						YES			
Question visible when scrolling for answer						NO			

Table A8  
 Characteristics of CAPT Science Items with Largest and Smallest Discrepancies Between Paper-  
 and-Pencil and Computer-Based Item Parameters

<b>LARGEST DISCREPANCIES</b>										
Item Number	7	11	13	6	22	16	27	8	9	25
2010 Bank Value	-0.91	0.14	0.55	-0.81	-1.00	0.20	-0.34	0.67	-0.75	0.39
Adjusted CBT Value*	0.01	0.80	0.07	-0.34	-0.61	-0.16	-0.08	0.90	-0.53	0.60
Difference	-0.93	-0.66	0.48	-0.47	-0.39	0.36	-0.26	-0.24	-0.22	-0.21
Item Type	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC
Presentation of answer changes on CB form	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Presentation changes from 2X2 matrix to 4X1										
Scrolling needed to answer question	YES	NO	NO	YES	NO	NO	NO	YES	NO	NO
Scrolls for question and answer are separate	YES			YES				YES		
Scrolling needed to see all answers (MC only)	YES			NO				NO		
Correct answer visible without scrolling (MC only)	NO									
Question visible when scrolling for answer	YES			YES				YES		
Question uses a table	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO
Question uses a plot or graph	YES	NO	NO	YES	NO	NO	NO	YES	NO	NO
Plot/graph displayed differently in CB test	NO			NO				NO		

\* For OE item instead of MC item, presentation of answer changes.

Table A8 (Continued)

Characteristics of CAPT Science Items with Largest and Smallest Discrepancies Between Paper-and-Pencil and Computer-Based Item Parameters

<b>SMALLEST DISCREPANCIES</b>										
Item Number	2	4	12	17	3	26	19	21	23	14
2010 Bank Value	0.57	-0.80	-0.30	0.93	-0.35	0.00	-0.19	-0.80	-0.27	-1.33
Adjusted CBT Value*	0.66	-0.89	-0.21	0.85	-0.27	-0.05	-0.23	-0.83	-0.25	-1.31
Difference	-0.10	0.09	-0.09	0.09	-0.08	0.05	0.04	0.03	-0.02	-0.02
Item Type	OE	MC	MC	MC	OE	MC	MC	MC	MC	MC
Presentation of answer changes on CB form	N	N	N	N	N	N	N	N	N	N
Presentation changes from 2X2 matrix to 4X1										
Scrolling needed to answer question	YES		YES	NO	YES	NO	NO	NO	NO	YES
Scrolls for question and answer are separate	NO		NO		NO					NO
Scrolling needed to see all answers (MC only)			NO							YES
Correct answer visible without scrolling (MC only)			YES							NO
Question visible when scrolling for answer	YES		NO		NO					NO
Question uses a table	NO	YES	YES	NO	NO	NO	NO	NO	NO	NO
Question uses a plot or graph	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES
Plot/graph displayed differently in CB test					NO					NO



Figure A1  
Plot of Computer-Based Reading Difficulty Estimates Against Paper-and-Pencil Bank Values

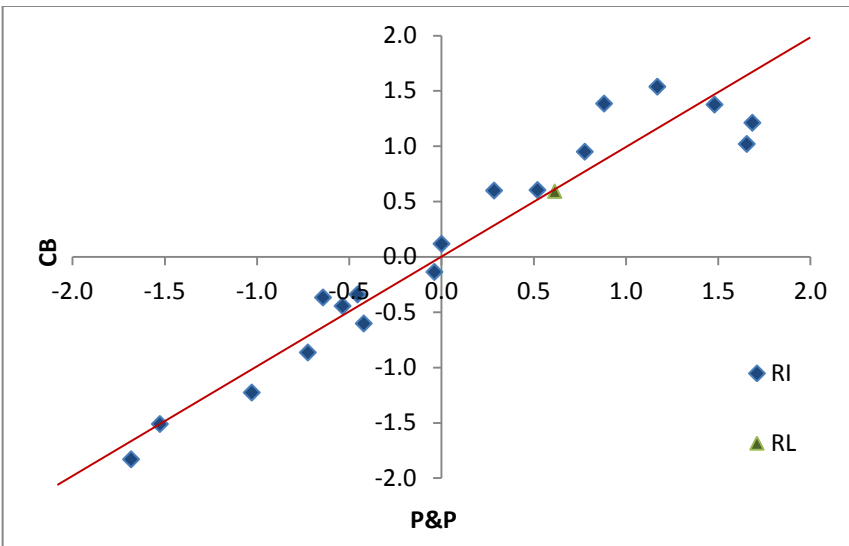


Figure A2  
Plot of 2012 Computer-Based Writing Difficulty Estimates Against Paper-and-Pencil Bank Values

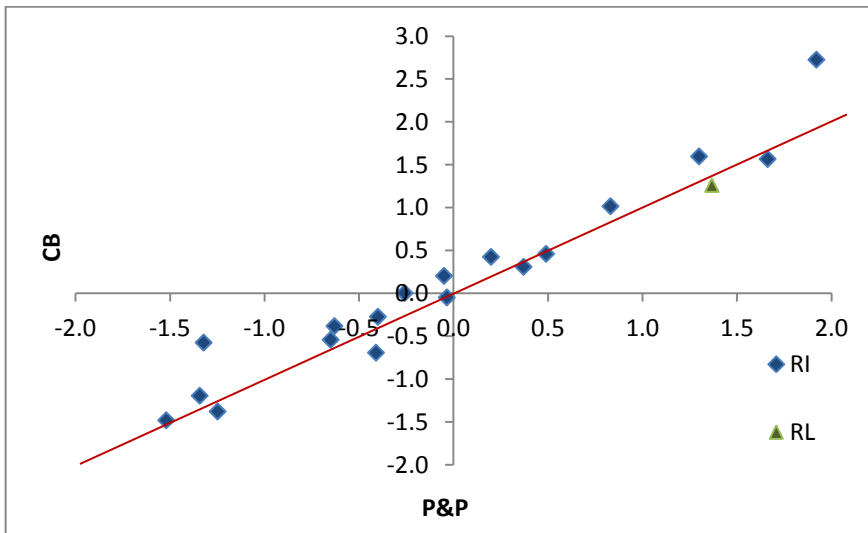


Figure A3  
Plot of 2012 Computer-Based Science Difficulty Estimates Against Paper-and-Pencil Bank Values

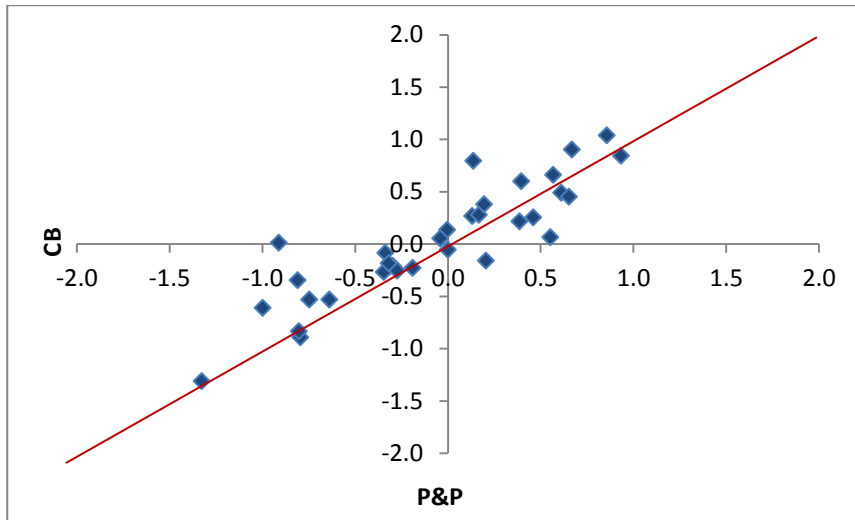
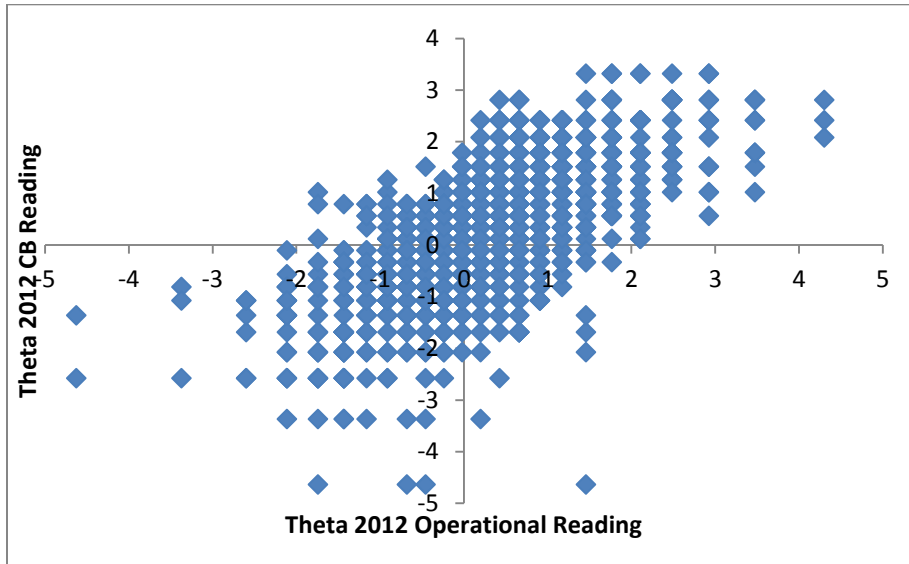


Figure A4

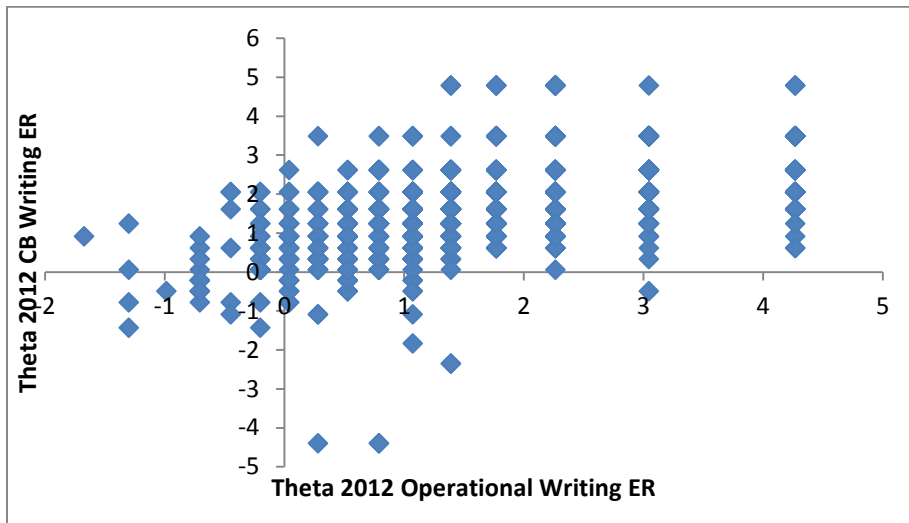
Plot of CAPT Reading CB Theta Estimates Against 2012 Operational Theta Estimates



$r = .70$

Figure A5

Plot of CAPT Writing CB Theta Estimates Against 2012 Operational Theta Estimates



$r = .51$

Figure A6

Plot of CAPT Science CB Theta Estimates Against 2012 Operational Theta Estimates

