Summary of the North Carolina Editions 1 and 2 Concordance Grade 8 Science

Pacific Metrics Corporation
1 Lower Ragsdale Drive
Building 1, Suite 150
Monterey, CA 93940

General Summary and Notes

The creation of the concordance between Edition 2 and Edition 1 grade 8 Science scale scores was conducted by Dr. Joshua Goodman from July 21st to July 23rd 2013, with oversight and review by Dr. Alan Nicewander.

The grade 8 Science test was administered in both paper/pencil and online formats, with three operational forms (A, B, & C for paper; M, N, & O for online) associated with each mode of delivery. The operational forms can be considered paired (A/M, B/N, and C/O) across modes where each form-pair, (with few exceptions) contain the same operational and concordance linking items. However, the form-pairs were calibrated in a manner that allowed corresponding items that perform differently across modes to have unique parameter values. As a result of the number of items and the magnitude of the differences in item parameters across item-pairs, Pacific Metrics completed a separate concordance table for each mode. The end results of the two concordances should be very similar and a decision to aggregate across modes to form a single concordance between editions was made in collaboration with NCDPI pscyhometricians.

General notes

- All item parameter inputs (including operational Edition 2 parameters, concordance linking items on Edition 2, and concordance linking items on the Edition 1 metric) to the concordance process where provided by NCDPI.
- All Edition 2 parameters were calibrated on the logistic metric (scaling constant D=1.0).
- The Edition 1 parameters were calibrated assuming a normal distribution (D=1.7).
- Scaling Edition 2 parameters to the Edition 1 bank scale was performed at the form level in order to avoid the assumption that the population receiving each form was equivalent.
- EAP scores and the associated scale scores were created using the entire pool of operational items.

Creation of Edition 2 EAP Estimates and Scale Scores

Using the entire set of Edition 2 operational item parameters, an EAP score and an associated Edition 2 scale score was estimated for each possible sum-score[1] using a program developed by program written by Dr. Goodman in the R statistical language[2]. It was essential to create these estimates in the same manner as the operational scoring tables created by NCDPI for each form using IRTPRO. To ensure that the methods used by Pacific Metrics in this step were congruent with NCPDI's process, Pacific Metrics re-created the operational scoring tables for each form and compared the results to NCDPI's RS-SS tables. Near perfect matches[3] were achieved when employing the following steps:

[1] In this case, the sum-score reflects a test using all 180 operational items across all three forms within a mode. The entire pool was used to define as many points along the entire scale as possible. The sum-score was be used to link the two sets of scale scores in the final concordance.

[2] This program was able to replicate the edition concordance between editions 2 and 3 that used the score10.exe program developed by David Thissen. The R scripts are available upon request.

[3] Across all six tables, differences of a single scale score point at two sum-scores on form A , one sum-score on form C, and one sum-score on form O were observed. Further exploration of the unrounded scale scores show that in each case, the unrounded scores fall just above 0.5, thus rounding up to the next scale score. These minute differences in the unrounded scale scores were likely due to differential rounding rules for the two RS-SS production processes.

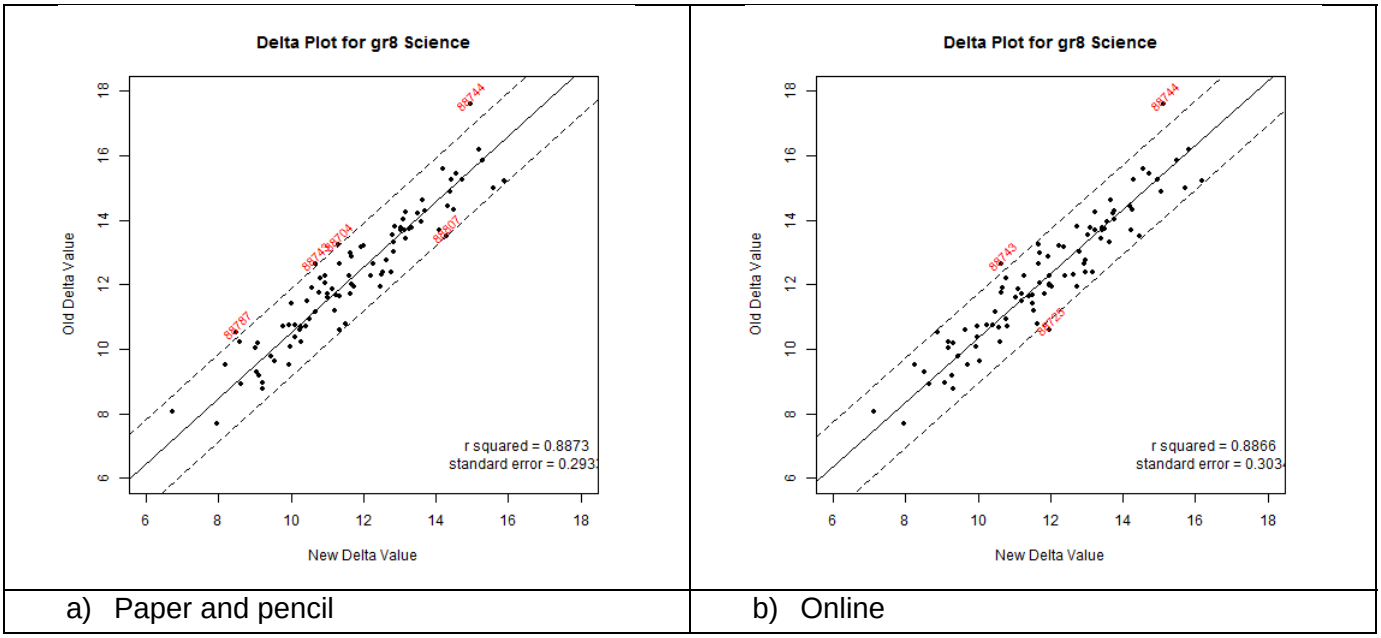
- Edition 2 parameters were rescaled to the normal metric by dividing each *a* parameter by 1.7
- EAP scores were produced using 33 quadrature points, ranging from -4.00 to 4.00 in intervals of 0.25.
- A standard normal prior was used in the estimation process.
- Scale scores were created by multiplying each EAP estimate by the Edition 2 scale score standard deviation (10) and adding the scale score mean (450). The resulting scores were rounded to the nearest integer.

The RS-SS tables produced in this step are found in the appendix (Table A1).

Screening for Anchor Item Stability

The set concordance linking items were screened for stability using a Delta plot (or Transformed Item Difficulty) method. This process assumes that the difficulty of the concordance linking items, if they are stable, will be *ordered* the same across the two editions despite being based on two different populations. Thus, instability was defined as significant differences in the relative difficulty of any item across editions. Item difficulties were transformed to the Delta scale and plotted. The plot's principal axis was defined, and items falling more than two standard errors away from this axis were flagged as unstable and removed from the linking process. For each mode of delivery, the entire set of linking items was screened in a single application of the Delta method.

For grade 8 Science, 5 items (88704, 88743, and 8744, 88787, and 8807) were flagged as unstable in the paper version of the test and three items (88725, 88743, and 8744) flagged as unstable on the online version. The 5 items flagged in the paper version all came from form A. After a discussion with NCDPI, it was determined that the scaling form-by-from should carry on as planned as form A still had ample linking items (25 items) and the scaling using all linking items led to an identical concordance table. The Delta plots for both modes are presented below. Results of the complete Delta analysis are found in the Appendix (Table A.2)



a) Paper and pencil

b) Online

Figure 1: Delta Plots for Paper and Online Versions of the Grade 8 Science Assessments

Rescaling the Edition 2 Parameters to the Edition 1 Bank Scale

Since the Edition 1 bank scale was established assuming a standard normal distribution (D=1.7) and the Edition 2 item parameters were calibrated with D=1.0 (a logistic distribution), the entire set of Edition 2 parameters (operational and concordance) were rescaled to be on the same metric as the Edition 1 parameters by dividing each *a* parameter by 1.7. Then, using the Edition 1 concordance item parameters and the normalized Edition 2 concordance item parameters, Stocking-Lord scaling constants were estimated two ways using a program developed by Dr. Goodman in the R statistical programing language[4]: 1) separately for each form; 2) using the entire set of linking items across all three forms. Given enough linking items, the form-by-from method of scaling was preferred as it dispenses with the assumption that each form was administered to an equivalent group. However, the scaling constants produced using the entire set of linking items was used as a QA step and provides an alternative scaling method should a large number of linking items be dropped from a single form or should a single form display a problematic scaling relationship.

Table 1 below displays the Stocking-Lord scaling constants for the two modes of administration by form and using the entire linking set. Figures 2 and 3 show the pre- and post-scaling TCC for each form and the overall linking set for the two modes. In all cases, post-scaling TCCs overlap almost completely. The normalized Edition 2 operational item parameters for each form were rescaled to the Edition 1 bank metric by applying the appropriate set of form-by-form Stocking-Lord scaling constants. The resulting item parameters were then reassembled into a single item pool for the next steps.

Table 1: Stocking-Lord Equating Constants

Form Pair	Paper		Online	
	A	B	A	B
A/M	0.9413	0.1860	0.9025	0.2430
B/N	0.8880	0.1883	0.8814	0.1842
C/O	0.9526	0.1367	0.9423	0.1534
All Items	0.9263	0.1693	0.9081	0.1919

[4] The IRT scaling R script that includes the estimation of S-L constants is available upon request. In the development of this program, the estimated constants under four methods were compared to the constants estimated by STUIRT (Kim and Kolen, 2004) and PLINK (Weeks, 2010) for several sets of item parameters. Results were identical to those estimated within PLINK and nearly identical to those estimated by STUIRT.

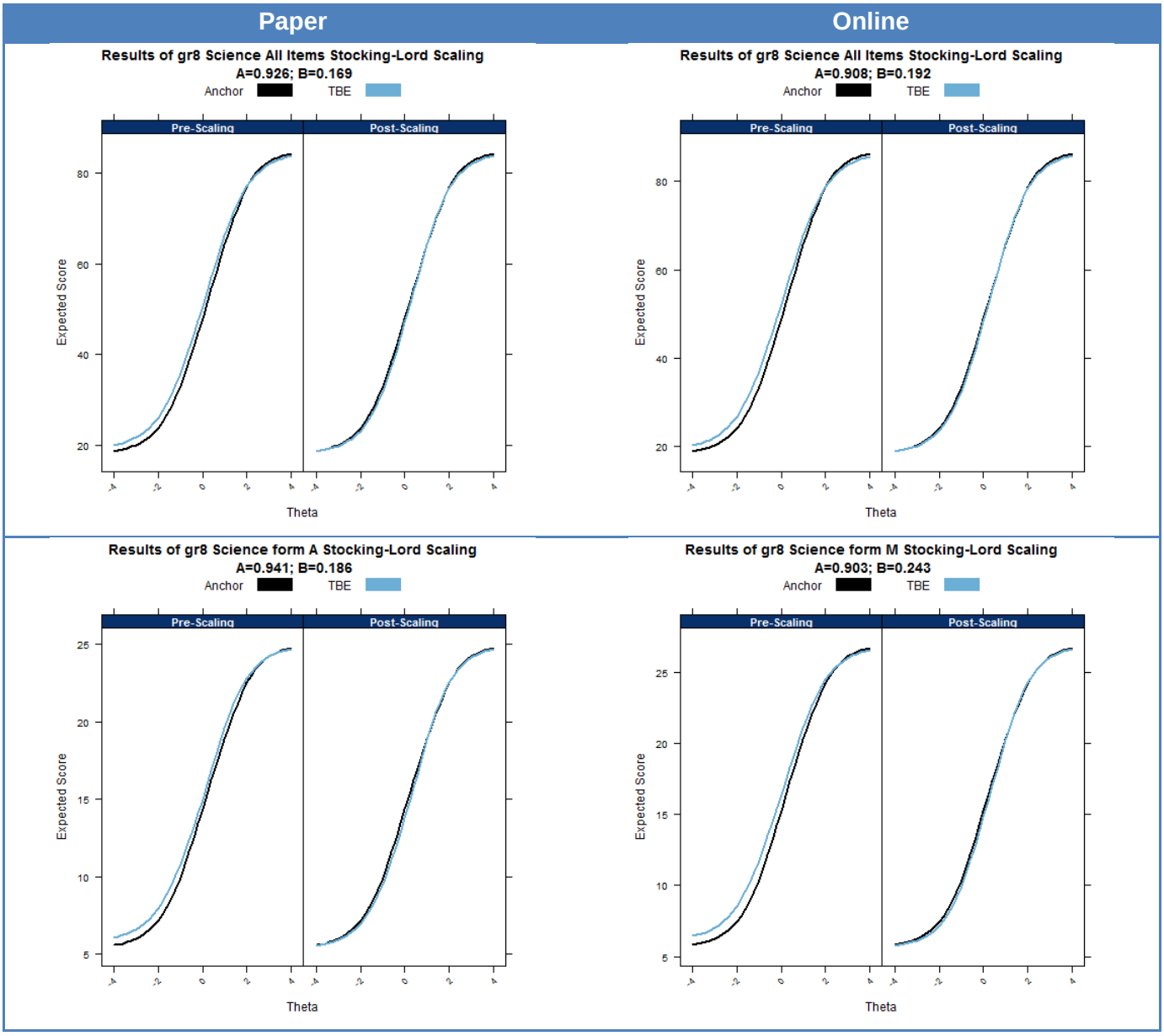


Figure 2: Pre- and Post-scaling TCC's for Entire Linking Set and Form Pair A/M

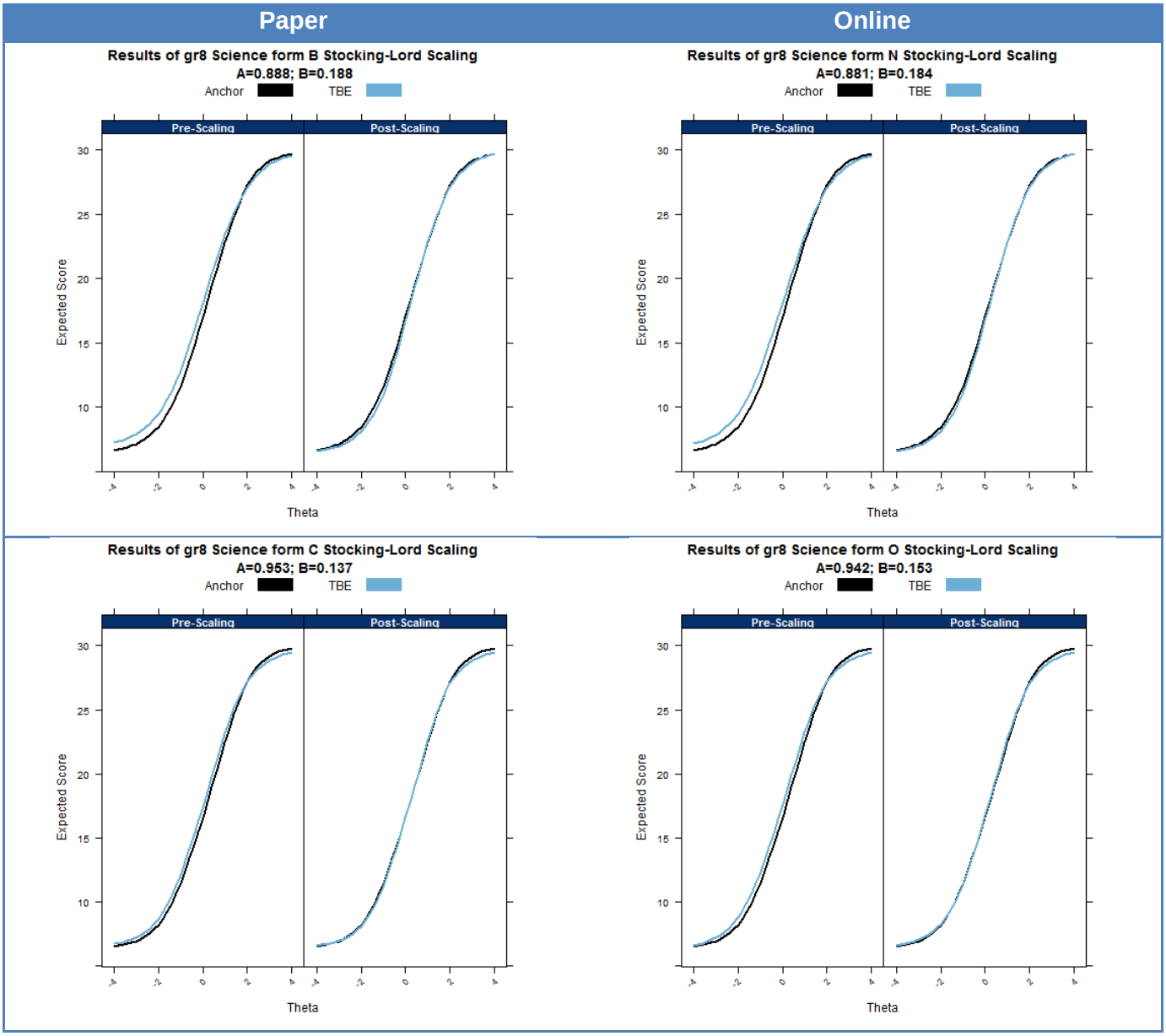


Figure 3: Pre- and Post-scaling TCC's for Form Pairs B/N and C/O

Creation of Edition 1 EAP estimates and Scale Scores Using Rescaled Parameters

Using the entire set of normalized and rescaled Edition 2 operational item parameters, an EAP score and corresponding Edition 1 scale scores were created for each possible sum-score[5]. The following steps are taken in the creation of these scores:

- EAP scores are produced using 33 quadrature points, ranging from -4.00 to 4.00 in intervals of 0.25.

[5] This process was carried out using the same program as described in the creation of the Edition 2 RS-SS tables.

- A standard normal prior is used in the estimation process.
- Scale scores are created by multiplying the EAP estimate by the Edition 1 scale score standard deviation (10) and adding the scale score mean (150). The resulting scores are rounded to the nearest integer.

The RS-SS tables produced in this step are found in the appendix (Table A3).

Creation of the Final Concordance tables

Merging, thinning, and interpolation

To create the initial concordance table, the Edition 2 tables and the Edition 1 tables based on all the operational items were merged by matching the sum-scores. The cut-scores (143,150, and 158) for Edition 1 were then applied to the Edition 1 scale scores in the table to show where the old proficiency classifications scores would fall on the Edition 2 scale.

The initial tables were thinned so that each Edition 2 scale score appears only once. If a scale score was replicated, table values associated with the lowest EAP values resulting in that Edition 2 scale score were retained. The final table must include values for the entire range of Edition 2 scale score values. For paper versions of the grade 8 Science concordance, there were no values for scores of 479,482, and 484 on the paper/pencil concordance and 478, 481, and 484 on the online concordance. Linear Interpolation was used to generate Edition 1 EAP estimates (which were then converted to Edition 1 scale scores as described above) for these missing values on the Edition 2 scale. Figures 4 and 5 depict the final concordance between the editions for the two modes of administration. Also plotted in these figures are the concordances that were based on the results of each individual form. In both modes, the results for concordances based on all items and forms are similar.

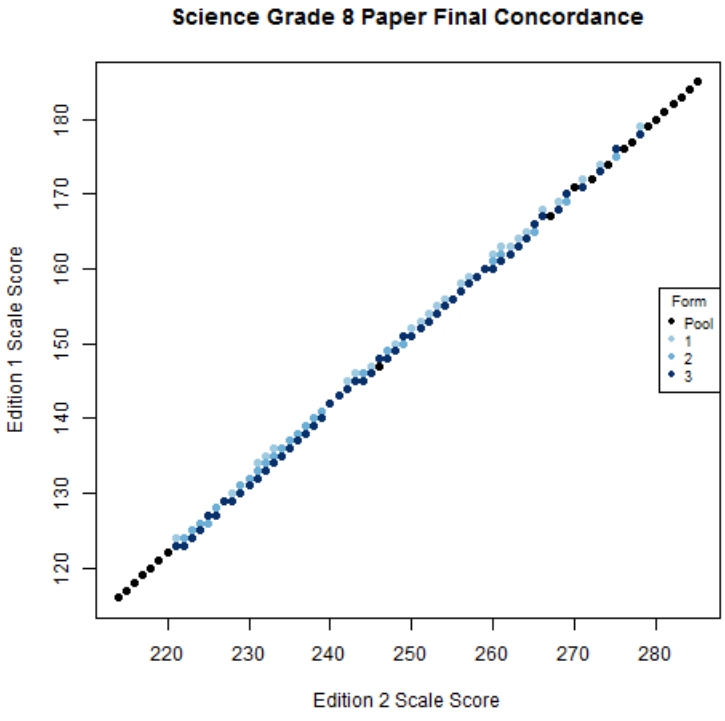


Figure 4: Final Concordance for Entire Pool and Forms A, B, & C

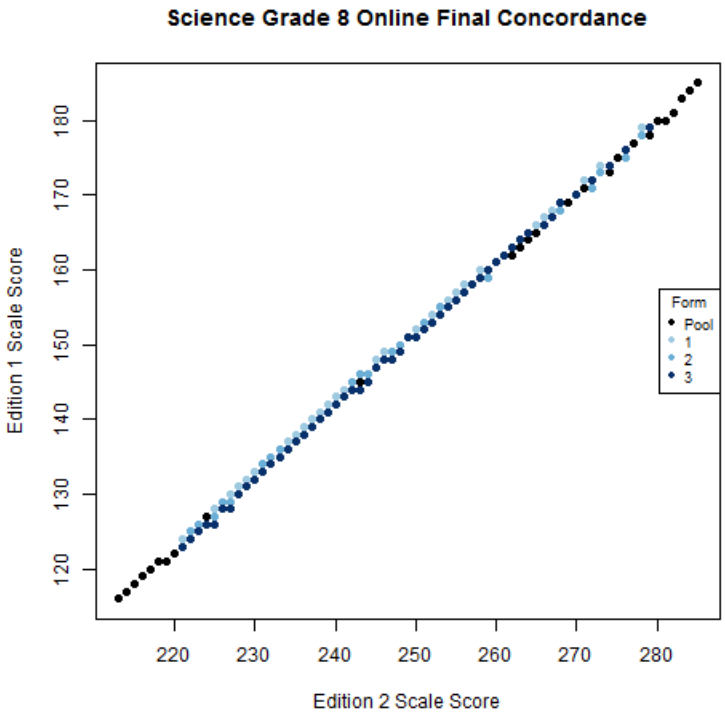


Figure 5: Final Concordance for Entire Pool and Forms M, N, & O

Comparison of Concordance Tables across Mode

The last step in creating the final concordances is to compare results across mode and decide on an approach for aggregation to create a single concordance relationship between editions. Figure 6 displays concordance for each mode. Overall, the relationship between Edition 2 and Edition 1 across mode is very similar with only a few minor differences at the two ends of score distribution. To create a single concordance relationship with the Edition 2 scale scores, the corresponding scale score for each model were averaged to create a single scale score equivalent for each Edition 2 scale point. The final Edition 2 to Edition 1 concordance table for grade 8 Science is presented in Table 2.

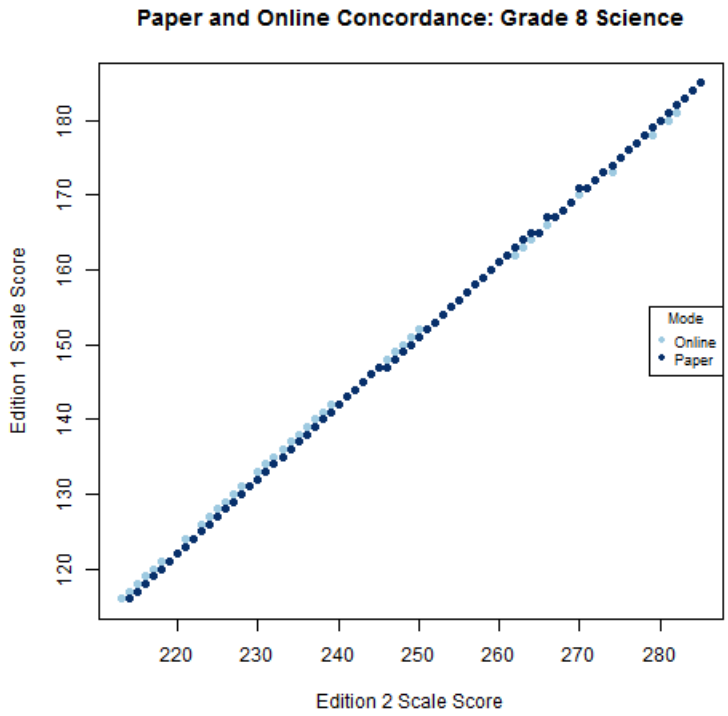


Figure 6: Comparison of Concordance Results across Mode of Administration

Table 2: Final Concordance Table for Grade 8 Science

Ed. 2 Score	Online		Paper		Final (Aggregate)	
	Ed. 1 Score	Perf. Level	Ed. 1 Score	Perf. Level	Ed. 1 Score	Perf. Level
213	116	1	.	.	116	1
214	117	1	116	1	117	1
215	118	1	117	1	118	1
216	119	1	118	1	119	1
217	120	1	119	1	120	1
218	121	1	120	1	121	1
219	121	1	121	1	121	1
220	122	1	122	1	122	1
221	124	1	123	1	124	1
222	124	1	124	1	124	1
223	126	1	125	1	126	1
224	127	1	126	1	127	1
225	128	1	127	1	128	1
226	129	1	128	1	129	1
227	130	1	129	1	130	1

Ed. 2 Score	Online		Paper		Final (Aggregate)	
	Ed. 1 Score	Perf. Level	Ed. 1 Score	Perf. Level	Ed. 1 Score	Perf. Level
228	131	1	130	1	131	1
229	131	1	131	1	131	1
230	133	1	132	1	133	1
231	134	1	133	1	134	1
232	135	1	134	1	135	1
233	136	1	135	1	136	1
234	137	1	136	1	137	1
235	138	1	137	1	138	1
236	139	1	138	1	139	1
237	140	1	139	1	140	1
238	141	1	140	1	141	1
239	142	1	141	1	142	1
240	142	1	142	1	142	1
241	143	2	143	2	143	2
242	144	2	144	2	144	2
243	145	2	145	2	145	2
244	146	2	146	2	146	2
245	147	2	147	2	147	2
246	148	2	148	2	148	2
247	149	2	149	2	149	2
248	150	3	150	3	150	3
249	151	3	150	3	151	3
250	152	3	151	3	152	3
251	152	3	152	3	152	3
252	153	3	153	3	153	3
253	154	3	154	3	154	3
254	155	3	155	3	155	3
255	156	3	156	3	156	3
256	157	3	157	3	157	3
257	158	4	158	4	158	4
258	159	4	159	4	159	4
259	160	4	160	4	160	4
260	161	4	161	4	161	4
261	162	4	162	4	162	4
262	162	4	163	4	163	4
263	163	4	164	4	164	4
264	164	4	165	4	165	4

Ed. 2 Score	Online		Paper		Final (Aggregate)	
	Ed. 1 Score	Perf. Level	Ed. 1 Score	Perf. Level	Ed. 1 Score	Perf. Level
265	165	4	165	4	165	4
266	166	4	166	4	166	4
267	167	4	167	4	167	4
268	168	4	168	4	168	4
269	169	4	169	4	169	4
270	170	4	170	4	170	4
271	171	4	171	4	171	4
272	172	4	172	4	172	4
273	173	4	173	4	173	4
274	174	4	174	4	174	4
275	175	4	175	4	175	4
276	176	4	176	4	176	4
277	177	4	177	4	177	4
278	178	4	178	4	178	4
279	178	4	178	4	178	4
280	180	4	179	4	180	4
281	180	4	181	4	181	4
282	181	4	182	4	182	4
283	183	4	183	4	183	4
284	184	4	184	4	184	4
285	185	4	185	4	185	4

APPENDIX

Table A.1: Edition 2 RS-SS Table Based on All Operational Items

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
0	-3.64	-3.66	0.43	0.43	214	213	4	4
1	-3.62	-3.64	0.43	0.43	214	214	4	4
2	-3.60	-3.62	0.43	0.43	214	214	4	4
3	-3.58	-3.60	0.44	0.43	214	214	4	4
4	-3.57	-3.58	0.44	0.44	214	214	4	4
5	-3.55	-3.56	0.44	0.44	215	214	4	4
6	-3.53	-3.54	0.44	0.44	215	215	4	4
7	-3.51	-3.52	0.45	0.45	215	215	4	4
8	-3.49	-3.50	0.45	0.45	215	215	4	4
9	-3.47	-3.48	0.45	0.45	215	215	5	5
10	-3.45	-3.46	0.45	0.45	216	215	5	5
11	-3.42	-3.43	0.46	0.46	216	216	5	5
12	-3.40	-3.41	0.46	0.46	216	216	5	5
13	-3.38	-3.38	0.46	0.46	216	216	5	5
14	-3.35	-3.36	0.46	0.46	216	216	5	5
15	-3.33	-3.33	0.46	0.46	217	217	5	5
16	-3.30	-3.30	0.47	0.47	217	217	5	5
17	-3.28	-3.27	0.47	0.47	217	217	5	5
18	-3.25	-3.24	0.47	0.47	218	218	5	5
19	-3.22	-3.21	0.47	0.47	218	218	5	5
20	-3.19	-3.18	0.47	0.47	218	218	5	5
21	-3.16	-3.15	0.47	0.47	218	219	5	5
22	-3.13	-3.12	0.47	0.48	219	219	5	5
23	-3.10	-3.08	0.48	0.48	219	219	5	5
24	-3.06	-3.05	0.48	0.48	219	220	5	5
25	-3.03	-3.01	0.48	0.48	220	220	5	5
26	-2.99	-2.97	0.48	0.48	220	220	5	5
27	-2.96	-2.93	0.48	0.48	220	221	5	5
28	-2.92	-2.89	0.48	0.48	221	221	5	5
29	-2.88	-2.85	0.48	0.48	221	222	5	5
30	-2.84	-2.80	0.48	0.47	222	222	5	5
31	-2.80	-2.76	0.48	0.47	222	222	5	5
32	-2.76	-2.72	0.47	0.47	222	223	5	5
33	-2.72	-2.67	0.47	0.47	223	223	5	5
34	-2.67	-2.62	0.47	0.46	223	224	5	5

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
35	-2.63	-2.57	0.47	0.46	224	224	5	5
36	-2.58	-2.52	0.46	0.46	224	225	5	5
37	-2.53	-2.47	0.46	0.45	225	225	5	5
38	-2.48	-2.42	0.46	0.45	225	226	5	4
39	-2.43	-2.37	0.45	0.44	226	226	5	4
40	-2.38	-2.31	0.45	0.43	226	227	4	4
41	-2.33	-2.26	0.44	0.43	227	227	4	4
42	-2.28	-2.20	0.43	0.42	227	228	4	4
43	-2.22	-2.15	0.43	0.41	228	229	4	4
44	-2.17	-2.10	0.42	0.40	228	229	4	4
45	-2.12	-2.04	0.41	0.39	229	230	4	4
46	-2.06	-1.99	0.40	0.38	229	230	4	4
47	-2.01	-1.93	0.40	0.38	230	231	4	4
48	-1.96	-1.88	0.39	0.37	230	231	4	4
49	-1.90	-1.83	0.38	0.36	231	232	4	4
50	-1.85	-1.77	0.37	0.35	231	232	4	3
51	-1.80	-1.72	0.36	0.34	232	233	4	3
52	-1.75	-1.67	0.35	0.33	233	233	3	3
53	-1.70	-1.63	0.34	0.32	233	234	3	3
54	-1.65	-1.58	0.33	0.31	234	234	3	3
55	-1.60	-1.53	0.32	0.30	234	235	3	3
56	-1.55	-1.48	0.31	0.29	234	235	3	3
57	-1.51	-1.44	0.30	0.28	235	236	3	3
58	-1.46	-1.40	0.29	0.28	235	236	3	3
59	-1.42	-1.35	0.29	0.27	236	236	3	3
60	-1.37	-1.31	0.28	0.26	236	237	3	3
61	-1.33	-1.27	0.27	0.26	237	237	3	3
62	-1.29	-1.23	0.26	0.25	237	238	3	3
63	-1.25	-1.19	0.26	0.24	238	238	3	2
64	-1.21	-1.15	0.25	0.24	238	238	3	2
65	-1.17	-1.12	0.25	0.23	238	239	2	2
66	-1.13	-1.08	0.24	0.23	239	239	2	2
67	-1.10	-1.04	0.23	0.22	239	240	2	2
68	-1.06	-1.01	0.23	0.22	239	240	2	2
69	-1.02	-0.97	0.23	0.22	240	240	2	2
70	-0.99	-0.94	0.22	0.21	240	241	2	2
71	-0.95	-0.91	0.22	0.21	240	241	2	2
72	-0.92	-0.87	0.21	0.20	241	241	2	2

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
73	-0.89	-0.84	0.21	0.20	241	242	2	2
74	-0.86	-0.81	0.21	0.20	241	242	2	2
75	-0.82	-0.78	0.20	0.20	242	242	2	2
76	-0.79	-0.75	0.20	0.19	242	243	2	2
77	-0.76	-0.72	0.20	0.19	242	243	2	2
78	-0.73	-0.69	0.19	0.19	243	243	2	2
79	-0.70	-0.66	0.19	0.19	243	243	2	2
80	-0.67	-0.63	0.19	0.18	243	244	2	2
81	-0.64	-0.60	0.19	0.18	244	244	2	2
82	-0.61	-0.57	0.18	0.18	244	244	2	2
83	-0.58	-0.54	0.18	0.18	244	245	2	2
84	-0.55	-0.52	0.18	0.17	244	245	2	2
85	-0.53	-0.49	0.18	0.17	245	245	2	2
86	-0.50	-0.46	0.17	0.17	245	245	2	2
87	-0.47	-0.43	0.17	0.17	245	246	2	2
88	-0.44	-0.41	0.17	0.17	246	246	2	2
89	-0.42	-0.38	0.17	0.17	246	246	2	2
90	-0.39	-0.35	0.17	0.17	246	246	2	2
91	-0.36	-0.33	0.17	0.16	246	247	2	2
92	-0.34	-0.30	0.16	0.16	247	247	2	2
93	-0.31	-0.27	0.16	0.16	247	247	2	2
94	-0.28	-0.25	0.16	0.16	247	248	2	2
95	-0.26	-0.22	0.16	0.16	247	248	2	2
96	-0.23	-0.20	0.16	0.16	248	248	2	2
97	-0.21	-0.17	0.16	0.16	248	248	2	2
98	-0.18	-0.15	0.16	0.16	248	249	2	2
99	-0.16	-0.12	0.16	0.16	248	249	2	2
100	-0.13	-0.09	0.16	0.16	249	249	2	2
101	-0.10	-0.07	0.16	0.15	249	249	2	2
102	-0.08	-0.04	0.15	0.15	249	250	2	2
103	-0.05	-0.02	0.15	0.15	249	250	2	2
104	-0.03	0.01	0.15	0.15	250	250	2	2
105	0.00	0.03	0.15	0.15	250	250	2	2
106	0.02	0.06	0.15	0.15	250	251	2	2
107	0.04	0.08	0.15	0.15	250	251	2	2
108	0.07	0.11	0.15	0.15	251	251	2	2
109	0.10	0.13	0.15	0.15	251	251	2	2
110	0.12	0.16	0.15	0.15	251	252	2	2

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
111	0.15	0.18	0.15	0.15	251	252	2	1
112	0.17	0.21	0.15	0.15	252	252	1	1
113	0.20	0.23	0.15	0.15	252	252	1	1
114	0.22	0.26	0.15	0.15	252	253	1	1
115	0.25	0.28	0.15	0.15	252	253	1	1
116	0.27	0.31	0.15	0.15	253	253	1	1
117	0.29	0.33	0.15	0.15	253	253	1	2
118	0.32	0.36	0.15	0.15	253	254	1	2
119	0.35	0.39	0.15	0.15	253	254	1	2
120	0.37	0.41	0.15	0.15	254	254	1	1
121	0.40	0.44	0.15	0.15	254	254	1	1
122	0.42	0.46	0.15	0.15	254	255	1	1
123	0.45	0.49	0.15	0.15	255	255	1	1
124	0.48	0.52	0.15	0.15	255	255	1	1
125	0.50	0.54	0.15	0.15	255	255	1	1
126	0.53	0.57	0.15	0.15	255	256	1	2
127	0.55	0.60	0.15	0.15	256	256	1	2
128	0.58	0.62	0.15	0.15	256	256	1	2
129	0.61	0.65	0.15	0.15	256	257	2	2
130	0.63	0.68	0.15	0.15	256	257	2	2
131	0.66	0.71	0.15	0.15	257	257	2	2
132	0.69	0.73	0.15	0.15	257	257	1	1
133	0.72	0.76	0.15	0.15	257	258	1	2
134	0.74	0.79	0.15	0.15	257	258	1	2
135	0.77	0.82	0.15	0.15	258	258	1	2
136	0.80	0.85	0.15	0.15	258	258	2	2
137	0.83	0.88	0.15	0.16	258	259	2	2
138	0.86	0.91	0.15	0.16	259	259	2	2
139	0.89	0.94	0.15	0.15	259	259	2	2
140	0.92	0.97	0.15	0.15	259	260	2	2
141	0.95	1.00	0.15	0.15	259	260	2	2
142	0.98	1.03	0.15	0.16	260	260	2	2
143	1.01	1.06	0.15	0.16	260	261	2	2
144	1.04	1.09	0.16	0.16	260	261	2	2
145	1.07	1.12	0.16	0.16	261	261	2	2
146	1.10	1.15	0.16	0.16	261	262	2	2
147	1.14	1.19	0.16	0.16	261	262	2	2
148	1.17	1.22	0.16	0.16	262	262	2	2

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
149	1.20	1.26	0.16	0.16	262	263	2	2
150	1.24	1.29	0.16	0.17	262	263	2	2
151	1.27	1.33	0.17	0.17	263	263	2	2
152	1.31	1.36	0.17	0.17	263	264	2	2
153	1.35	1.40	0.17	0.17	263	264	2	2
154	1.38	1.44	0.17	0.17	264	264	2	2
155	1.42	1.48	0.17	0.17	264	265	2	2
156	1.46	1.52	0.18	0.18	265	265	2	2
157	1.50	1.56	0.18	0.18	265	266	2	2
158	1.55	1.60	0.18	0.18	265	266	2	2
159	1.59	1.65	0.18	0.19	266	266	2	2
160	1.64	1.69	0.19	0.19	266	267	2	2
161	1.68	1.74	0.19	0.19	267	267	2	2
162	1.73	1.79	0.19	0.20	267	268	2	2
163	1.78	1.84	0.20	0.20	268	268	2	2
164	1.83	1.89	0.20	0.21	268	269	2	2
165	1.89	1.95	0.21	0.21	269	269	2	2
166	1.95	2.01	0.21	0.22	269	270	2	2
167	2.01	2.07	0.22	0.22	270	271	2	2
168	2.07	2.13	0.23	0.23	271	271	2	2
169	2.14	2.20	0.24	0.24	271	272	2	2
170	2.22	2.28	0.25	0.25	272	273	2	2
171	2.29	2.35	0.26	0.26	273	274	3	3
172	2.38	2.44	0.27	0.27	274	274	3	3
173	2.47	2.53	0.28	0.28	275	275	3	3
174	2.57	2.64	0.30	0.30	276	276	3	3
175	2.69	2.75	0.32	0.32	277	277	3	3
176	2.81	2.87	0.34	0.34	278	279	3	3
177	2.95	3.01	0.36	0.36	280	280	4	4
178	3.11	3.17	0.39	0.39	281	282	4	4
179	3.29	3.35	0.42	0.41	283	283	4	4
180	3.49	3.54	0.43	0.43	285	285	4	4

Table A.2: Delta Results

UIN	Form-Pair	P-value (Ed. 1)	Delta (Ed. 1)	P-value (Ed. 2)		Delta (Ed. 2)		Standardized Residual	
				Paper	Online	Paper	Online	Paper	Online
88685	AM	0.70	10.94	0.73	0.71	10.51	10.77	-1.01	-0.83
88687	AM	0.41	13.95	0.44	0.44	13.61	13.56	-0.73	-1.09
88704	AM	0.48	13.24	0.66	0.63	11.30	11.68	**2.06**	1.60
88705	AM	0.47	13.31	0.52	0.44	12.83	13.64	-1.07	0.32
88707	AM	0.77	10.04	0.84	0.83	9.03	9.20	-0.10	-0.08
88714	AM	0.21	16.17	0.29	0.24	15.20	15.83	-0.37	-1.19
88716	AM	0.53	12.66	0.57	0.51	12.26	12.93	-0.89	0.20
88717	AM	0.85	8.92	0.86	0.86	8.61	8.64	-0.80	-1.06
88722	AM	0.72	10.69	0.74	0.71	10.40	10.82	-0.70	-0.14
88725	AM	0.73	10.61	0.66	0.60	11.35	11.98	1.80	**2.75**
88727	AM	0.29	15.24	0.33	0.31	14.71	14.95	-1.14	-1.14
88742	AM	0.51	12.89	0.63	0.60	11.68	11.94	0.29	0.20
88743	AM	0.54	12.63	0.72	0.72	10.67	10.65	**2.14**	**2.60**
88744	AM	0.12	17.61	0.31	0.30	14.94	15.12	**3.70**	**3.82**
88752	AM	0.50	12.96	0.63	0.63	11.65	11.70	0.55	0.92
88772	AM	0.76	10.18	0.84	0.82	9.08	9.30	0.11	0.00
88773	AM	0.76	10.22	0.87	0.83	8.59	9.17	1.43	0.41
88774	AM	0.27	15.44	0.35	0.33	14.56	14.73	-0.58	-0.35
88787	AM	0.73	10.50	0.87	0.85	8.49	8.89	**2.33**	1.72
88794	AM	0.72	10.67	0.75	0.73	10.26	10.56	-0.98	-0.69
88798	AM	0.76	10.23	0.75	0.73	10.27	10.60	0.11	0.44
88800	AM	0.40	14.03	0.49	0.42	13.09	13.76	-0.39	-1.08
88807	AM	0.45	13.48	0.37	0.36	14.29	14.47	2.05	1.83
88809	AM	0.38	14.22	0.45	0.43	13.48	13.73	-0.88	-0.86
88843	AM	0.79	9.78	0.81	0.81	9.45	9.44	-0.81	-1.21
88846	AM	0.71	10.76	0.65	0.63	11.50	11.65	1.81	1.63
88847	AM	0.53	12.66	0.66	0.63	11.33	11.66	0.60	0.30
88850	AM	0.63	11.67	0.67	0.65	11.23	11.50	-1.03	-0.84
88854	AM	0.43	13.70	0.49	0.46	13.12	13.43	-1.24	-1.08
88860	AM	0.68	11.15	0.72	0.74	10.69	10.48	-1.08	-0.48
88686	BN	0.73	10.58	0.75	0.80	10.24	9.65	-0.83	0.14
88688	BN	0.42	13.77	0.47	0.49	13.34	13.10	-0.92	-0.46
88701	BN	0.62	11.73	0.71	0.72	10.79	10.63	-0.30	0.54
88702	BN	0.63	11.70	0.63	0.61	11.64	11.83	-0.09	-0.12
88708	BN	0.60	11.98	0.63	0.60	11.71	11.97	-0.60	-0.48
88720	BN	0.50	13.01	0.52	0.52	12.83	12.79	-0.35	-0.97

UIN	Form-Pair	P-value (Ed. 1)	Delta (Ed. 1)	P-value (Ed. 2)		Delta (Ed. 2)		Standardized Residual	
				Paper	Online	Paper	Online	Paper	Online
88721	BN	0.63	11.63	0.66	0.66	11.33	11.40	-0.69	-0.98
88724	BN	0.61	11.86	0.68	0.68	11.14	11.12	-0.86	-0.30
88726	BN	0.31	14.99	0.26	0.25	15.58	15.71	1.57	1.22
88737	BN	0.43	13.71	0.39	0.38	14.09	14.21	1.04	0.72
88739	BN	0.57	12.28	0.70	0.67	10.93	11.28	0.68	0.32
88748	BN	0.44	13.56	0.52	0.50	12.78	13.03	-0.78	-0.78
88755	BN	0.56	12.38	0.55	0.50	12.52	12.97	0.41	0.92
88756	BN	0.37	14.34	0.36	0.38	14.48	14.26	0.47	-0.63
88757	BN	0.42	13.80	0.51	0.53	12.87	12.74	-0.41	0.46
88759	BN	0.29	15.24	0.36	0.37	14.41	14.28	-0.70	0.23
88763	BN	0.61	11.93	0.55	0.53	12.47	12.72	1.37	1.41
88779	BN	0.81	9.52	0.88	0.88	8.20	8.25	0.67	0.91
88780	BN	0.65	11.41	0.77	0.65	10.01	11.51	0.81	-0.20
88782	BN	0.58	12.19	0.71	0.71	10.83	10.79	0.71	1.25
88786	BN	0.71	10.75	0.76	0.74	10.12	10.40	-1.02	-1.22
88789	BN	0.36	14.42	0.37	0.38	14.32	14.18	-0.13	-1.02
88808	BN	0.48	13.21	0.60	0.58	11.99	12.22	0.31	0.28
88810	BN	0.81	9.52	0.78	0.79	9.96	9.73	1.04	0.05
88822	BN	0.82	9.28	0.84	0.87	9.06	8.51	-0.57	-0.25
88828	BN	0.64	11.60	0.69	0.69	11.01	11.04	-1.18	-0.72
88842	BN	0.77	10.08	0.78	0.78	9.98	9.96	-0.25	-0.70
89341	BN	0.42	13.76	0.50	0.46	13.02	13.43	-0.87	-1.21
89342	BN	0.91	7.68	0.90	0.90	7.96	7.96	0.58	0.25
89343	BN	0.57	12.33	0.55	0.54	12.49	12.63	0.46	0.26
88682	CO	0.63	11.72	0.69	0.67	10.99	11.21	-0.84	-0.85
88684	CO	0.59	12.05	0.70	0.63	10.93	11.72	0.12	-1.22
88698	CO	0.61	11.88	0.73	0.72	10.59	10.67	0.55	0.81
88699	CO	0.86	8.76	0.83	0.82	9.20	9.32	1.03	0.90
88703	CO	0.83	9.19	0.83	0.82	9.13	9.28	-0.18	-0.21
88706	CO	0.75	10.36	0.76	0.77	10.12	9.99	-0.59	-1.19
88713	CO	0.38	14.26	0.49	0.48	13.15	13.23	0.02	0.38
88718	CO	0.52	12.77	0.54	0.50	12.62	12.98	-0.29	0.04
88723	CO	0.24	15.86	0.28	0.27	15.29	15.47	-1.22	-1.08
88741	CO	0.65	11.49	0.74	0.67	10.44	11.19	-0.03	-1.13
88745	CO	0.43	13.72	0.47	0.45	13.27	13.49	-0.98	-0.98
88746	CO	0.84	8.95	0.83	0.84	9.23	9.08	0.63	-0.11
88749	CO	0.34	14.62	0.44	0.44	13.63	13.65	-0.28	0.25

UIN	Form-Pair	P-value (Ed. 1)	Delta (Ed. 1)	P-value (Ed. 2)		Delta (Ed. 2)		Standardized Residual	
				Paper	Online	Paper	Online	Paper	Online
88753	CO	0.61	11.92	0.62	0.60	11.75	12.03	-0.36	-0.18
88754	CO	0.72	10.72	0.79	0.78	9.78	9.97	-0.28	-0.29
88762	CO	0.37	14.29	0.43	0.42	13.70	13.78	-1.25	-0.81
88764	CO	0.89	8.05	0.94	0.93	6.73	7.13	0.74	0.10
88765	CO	0.29	15.23	0.23	0.21	15.90	16.18	1.77	1.75
88767	CO	0.48	13.18	0.60	0.56	11.94	12.38	0.38	-0.15
88768	CO	0.57	12.28	0.64	0.60	11.61	11.97	-0.98	-1.16
88769	CO	0.46	13.44	0.48	0.46	13.16	13.40	-0.58	-0.55
88784	CO	0.67	11.19	0.67	0.64	11.21	11.52	0.10	0.35
88790	CO	0.32	14.87	0.36	0.30	14.39	15.06	-1.03	-0.02
88792	CO	0.57	12.28	0.58	0.56	12.19	12.40	-0.15	-0.16
88796	CO	0.43	13.70	0.50	0.48	13.02	13.22	-1.02	-0.90
88816	CO	0.60	11.99	0.63	0.60	11.66	11.97	-0.76	-0.48
88832	CO	0.56	12.38	0.52	0.48	12.77	13.16	1.00	1.35
88837	CO	0.80	9.63	0.81	0.77	9.54	10.03	-0.25	0.51
88841	CO	0.71	10.74	0.78	0.75	9.96	10.26	-0.65	-0.90
88849	CO	0.26	15.57	0.38	0.35	14.18	14.55	0.66	0.39

Table A.3: Edition 1 RS-SS Table Based on All Operational Items

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
0	-3.38	-3.35	0.46	0.46	116	116	5	5
1	-3.37	-3.33	0.46	0.46	116	117	5	5
2	-3.35	-3.32	0.46	0.46	117	117	5	5
3	-3.33	-3.30	0.46	0.46	117	117	5	5
4	-3.31	-3.28	0.46	0.47	117	117	5	5
5	-3.30	-3.26	0.46	0.47	117	117	5	5
6	-3.28	-3.24	0.47	0.47	117	118	5	5
7	-3.26	-3.22	0.47	0.47	117	118	5	5
8	-3.24	-3.20	0.47	0.47	118	118	5	5
9	-3.22	-3.18	0.47	0.47	118	118	5	5
10	-3.20	-3.15	0.47	0.48	118	118	5	5
11	-3.18	-3.13	0.47	0.48	118	119	5	5
12	-3.15	-3.11	0.48	0.48	118	119	5	5
13	-3.13	-3.08	0.48	0.48	119	119	5	5
14	-3.11	-3.06	0.48	0.48	119	119	5	5
15	-3.08	-3.03	0.48	0.48	119	120	5	5
16	-3.06	-3.01	0.48	0.48	119	120	5	5
17	-3.03	-2.98	0.48	0.49	120	120	5	5
18	-3.00	-2.95	0.48	0.49	120	121	5	5
19	-2.98	-2.92	0.48	0.49	120	121	5	5
20	-2.95	-2.89	0.49	0.49	121	121	5	5
21	-2.92	-2.86	0.49	0.49	121	121	5	5
22	-2.89	-2.83	0.49	0.49	121	122	5	5
23	-2.86	-2.79	0.49	0.49	121	122	5	5
24	-2.83	-2.76	0.49	0.49	122	122	5	5
25	-2.79	-2.72	0.49	0.49	122	123	5	5
26	-2.76	-2.68	0.49	0.49	122	123	5	5
27	-2.72	-2.65	0.49	0.49	123	124	5	5
28	-2.69	-2.61	0.49	0.49	123	124	5	5
29	-2.65	-2.56	0.49	0.49	124	124	5	5
30	-2.61	-2.52	0.49	0.49	124	125	5	5
31	-2.57	-2.48	0.49	0.48	124	125	5	5
32	-2.53	-2.43	0.49	0.48	125	126	5	5
33	-2.48	-2.39	0.48	0.48	125	126	5	5
34	-2.44	-2.34	0.48	0.48	126	127	5	5
35	-2.39	-2.29	0.48	0.47	126	127	5	5
36	-2.35	-2.24	0.48	0.47	127	128	5	5

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
37	-2.30	-2.19	0.47	0.46	127	128	5	5
38	-2.25	-2.13	0.47	0.46	128	129	5	5
39	-2.20	-2.08	0.46	0.45	128	129	5	5
40	-2.15	-2.03	0.46	0.44	129	130	5	4
41	-2.09	-1.97	0.45	0.44	129	130	5	4
42	-2.04	-1.92	0.44	0.43	130	131	4	4
43	-1.99	-1.86	0.44	0.42	130	131	4	4
44	-1.93	-1.81	0.43	0.41	131	132	4	4
45	-1.88	-1.75	0.42	0.40	131	133	4	4
46	-1.82	-1.69	0.41	0.39	132	133	4	4
47	-1.77	-1.64	0.40	0.38	132	134	4	4
48	-1.72	-1.59	0.39	0.36	133	134	4	4
49	-1.66	-1.53	0.38	0.35	133	135	4	4
50	-1.61	-1.48	0.37	0.34	134	135	4	3
51	-1.56	-1.43	0.36	0.33	134	136	4	3
52	-1.50	-1.38	0.35	0.32	135	136	3	3
53	-1.45	-1.33	0.33	0.31	135	137	3	3
54	-1.40	-1.28	0.32	0.30	136	137	3	3
55	-1.36	-1.24	0.31	0.29	136	138	3	3
56	-1.31	-1.19	0.30	0.28	137	138	3	3
57	-1.26	-1.15	0.29	0.27	137	139	3	3
58	-1.22	-1.11	0.29	0.26	138	139	3	3
59	-1.17	-1.07	0.28	0.26	138	139	3	3
60	-1.13	-1.03	0.27	0.25	139	140	3	2
61	-1.09	-0.99	0.26	0.24	139	140	3	2
62	-1.05	-0.95	0.25	0.24	139	141	3	2
63	-1.01	-0.91	0.25	0.23	140	141	2	2
64	-0.97	-0.88	0.24	0.22	140	141	2	2
65	-0.94	-0.84	0.23	0.22	141	142	2	2
66	-0.90	-0.81	0.23	0.21	141	142	2	2
67	-0.86	-0.77	0.22	0.21	141	142	2	2
68	-0.83	-0.74	0.22	0.20	142	143	2	2
69	-0.80	-0.71	0.21	0.20	142	143	2	2
70	-0.76	-0.68	0.21	0.20	142	143	2	2
71	-0.73	-0.64	0.21	0.19	143	144	2	2
72	-0.70	-0.61	0.20	0.19	143	144	2	2
73	-0.67	-0.58	0.20	0.19	143	144	2	2
74	-0.63	-0.56	0.19	0.18	144	144	2	2

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
75	-0.60	-0.53	0.19	0.18	144	145	2	2
76	-0.57	-0.50	0.19	0.18	144	145	2	2
77	-0.55	-0.47	0.18	0.18	145	145	2	2
78	-0.52	-0.44	0.18	0.17	145	146	2	2
79	-0.49	-0.41	0.18	0.17	145	146	2	2
80	-0.46	-0.39	0.18	0.17	145	146	2	2
81	-0.43	-0.36	0.17	0.17	146	146	2	2
82	-0.40	-0.33	0.17	0.16	146	147	2	2
83	-0.38	-0.31	0.17	0.16	146	147	2	2
84	-0.35	-0.28	0.17	0.16	146	147	2	2
85	-0.32	-0.26	0.16	0.16	147	147	2	2
86	-0.30	-0.23	0.16	0.16	147	148	2	2
87	-0.27	-0.21	0.16	0.16	147	148	2	2
88	-0.25	-0.18	0.16	0.16	148	148	2	2
89	-0.22	-0.16	0.16	0.15	148	148	2	2
90	-0.20	-0.13	0.16	0.15	148	149	2	2
91	-0.17	-0.11	0.16	0.15	148	149	2	2
92	-0.15	-0.08	0.16	0.15	149	149	2	1
93	-0.12	-0.06	0.15	0.15	149	149	2	1
94	-0.10	-0.04	0.15	0.14	149	150	2	1
95	-0.07	-0.01	0.15	0.14	149	150	1	1
96	-0.05	0.01	0.15	0.14	150	150	1	1
97	-0.03	0.03	0.15	0.14	150	150	1	1
98	0.00	0.06	0.15	0.14	150	151	1	1
99	0.02	0.08	0.15	0.15	150	151	1	1
100	0.04	0.10	0.15	0.15	150	151	1	1
101	0.07	0.13	0.15	0.14	151	151	1	1
102	0.09	0.15	0.15	0.14	151	152	1	1
103	0.12	0.18	0.15	0.14	151	152	1	1
104	0.14	0.20	0.15	0.14	151	152	1	1
105	0.17	0.22	0.14	0.13	152	152	1	1
106	0.19	0.24	0.14	0.13	152	152	1	1
107	0.21	0.26	0.14	0.13	152	153	1	1
108	0.23	0.28	0.14	0.14	152	153	1	1
109	0.26	0.31	0.14	0.14	153	153	1	1
110	0.28	0.33	0.14	0.14	153	153	1	1
111	0.30	0.36	0.14	0.14	153	154	1	1
112	0.32	0.38	0.14	0.14	153	154	1	1

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
113	0.35	0.41	0.14	0.14	153	154	1	1
114	0.37	0.43	0.14	0.14	154	154	1	1
115	0.40	0.45	0.14	0.13	154	155	1	1
116	0.42	0.47	0.14	0.13	154	155	1	1
117	0.45	0.50	0.14	0.13	154	155	1	1
118	0.47	0.52	0.13	0.13	155	155	1	1
119	0.49	0.54	0.13	0.13	155	155	1	1
120	0.51	0.56	0.13	0.14	155	156	1	1
121	0.54	0.59	0.13	0.14	155	156	1	1
122	0.56	0.61	0.14	0.14	156	156	1	1
123	0.58	0.64	0.14	0.14	156	156	1	1
124	0.61	0.66	0.14	0.14	156	157	1	1
125	0.63	0.69	0.14	0.14	156	157	1	1
126	0.66	0.71	0.14	0.13	157	157	1	1
127	0.69	0.74	0.14	0.13	157	157	1	1
128	0.71	0.76	0.14	0.13	157	158	1	1
129	0.73	0.78	0.13	0.13	157	158	1	1
130	0.76	0.81	0.13	0.14	158	158	1	1
131	0.78	0.83	0.14	0.14	158	158	1	1
132	0.81	0.86	0.14	0.14	158	159	1	1
133	0.83	0.89	0.14	0.14	158	159	1	1
134	0.86	0.91	0.14	0.14	159	159	1	1
135	0.89	0.94	0.14	0.14	159	159	1	1
136	0.91	0.96	0.14	0.14	159	160	1	1
137	0.94	0.99	0.14	0.14	159	160	1	1
138	0.97	1.02	0.14	0.14	160	160	1	1
139	0.99	1.04	0.14	0.14	160	160	1	1
140	1.02	1.07	0.14	0.14	160	161	1	1
141	1.05	1.10	0.14	0.14	160	161	1	1
142	1.08	1.13	0.14	0.15	161	161	1	1
143	1.10	1.16	0.15	0.15	161	162	1	1
144	1.13	1.19	0.15	0.15	161	162	1	1
145	1.17	1.22	0.15	0.14	162	162	1	1
146	1.20	1.24	0.15	0.14	162	162	1	1
147	1.23	1.27	0.15	0.15	162	163	1	1
148	1.26	1.30	0.15	0.15	163	163	1	1
149	1.29	1.34	0.15	0.15	163	163	1	2
150	1.32	1.37	0.15	0.15	163	164	2	2

X	EAP|X		SD(EAP|X)		Scale Score		SD(Scale Score)	
	Paper	Online	Paper	Online	Paper	Online	Paper	Online
151	1.35	1.40	0.15	0.15	164	164	2	2
152	1.39	1.44	0.16	0.15	164	164	2	2
153	1.42	1.47	0.16	0.16	164	165	2	2
154	1.46	1.50	0.16	0.16	165	165	2	2
155	1.49	1.54	0.16	0.16	165	165	2	2
156	1.53	1.58	0.16	0.16	165	166	2	2
157	1.57	1.61	0.17	0.16	166	166	2	2
158	1.61	1.65	0.17	0.17	166	167	2	2
159	1.65	1.69	0.17	0.17	166	167	2	2
160	1.69	1.74	0.17	0.17	167	167	2	2
161	1.73	1.78	0.18	0.18	167	168	2	2
162	1.78	1.82	0.18	0.18	168	168	2	2
163	1.83	1.87	0.19	0.18	168	169	2	2
164	1.88	1.92	0.19	0.19	169	169	2	2
165	1.93	1.97	0.19	0.19	169	170	2	2
166	1.98	2.03	0.20	0.20	170	170	2	2
167	2.04	2.08	0.21	0.20	170	171	2	2
168	2.10	2.14	0.21	0.21	171	171	2	2
169	2.16	2.21	0.22	0.22	172	172	2	2
170	2.23	2.28	0.23	0.23	172	173	2	2
171	2.31	2.35	0.24	0.24	173	174	2	2
172	2.39	2.43	0.25	0.25	174	174	3	2
173	2.48	2.52	0.27	0.26	175	175	3	3
174	2.58	2.62	0.28	0.28	176	176	3	3
175	2.68	2.72	0.30	0.30	177	177	3	3
176	2.81	2.84	0.32	0.32	178	178	3	3
177	2.94	2.98	0.35	0.34	179	180	3	3
178	3.10	3.14	0.37	0.37	181	181	4	4
179	3.28	3.31	0.40	0.40	183	183	4	4
180	3.48	3.51	0.43	0.42	185	185	4	4