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Validity and Reliability of Students' Science and Technology Culture Instrument (BST-M) using Rasch Measurement Model

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Abstract

Students' Science and Technology Culture Instrument (*Budaya Sains dan Teknologi Murid,* BST-M) was developed to measure the level of Science and Technology Culture among the students. A total of 800 Form Two students from several schools in Seremban, Negeri Sembilan have been selected as a sample study. This study was conducted to determine the reliability and construct validity of the instrument using Rasch Model via Winstep 3.73 software. The constructs consist of Value and Perception on Science and Technology (B); Perception on Science and Technology (C); Scientific Attitude and Common Practice (D); Scientific Mind Habits and Environmental Concerns (E); and Personality Traits (F). From the analysis, it is found that PTMEA Corr has a positive value, in which items are able to differentiate the capabilities of the respondents. Besides, the results of infit and outfit mean square are ranged between 0.60 and 1.4. The quality of items is high because the reliability value is also high. In addition, the separation of item and person is at the acceptable range. However, statistical data shows that 8 out of 110 items need to be modified.

Keywords: Validity and Reliability of Instrument, Rasch Measurement Model, Construct Validity.

Introduction

The rapid development of science and technology (S&T) in the 21st century can be obviously seen. Likewise, the growth has a massive effect in human's life. Nowadays, the use of technology and scientific equipment's or devices in daily life is very important. Several examples are including telecommunication technologies such as smart phones, computers, and the Internet. In fact, the use of motor vehicles and other tools related to the basis of scientific knowledge are also very significant in this modern era. Recently, S&T knowledge has become the basis of development and progress of most countries in this world. There is an increase in the number of professions

that requires to be linked with science concepts and high technology tools. In addition, the future of society needs to be decided based on scientific knowledge (Lee & Luykx, 2007). Consequently, Malaysia Education plays a major role in developing scientific knowledge among the younger generation in line with Vision 2020's goals. This is due to the fact that S&T field is very crucial. Thus, the development and enrichment of Science and Technology Culture among students in Malaysia are believed to be achievable and feasible (Curriculum Development Centre, 2003).

However, the decline in secondary-level students' participation in S&T field needs to be taken into consideration. Even though the percentage of qualified students pursuing S&T field is higher, but the percentage of actual S&T students is lower than that. MOE statistics show that the participation of students in science field from 2001 to 2011 has never achieved the 60:40 target ratio of science to non-science students as aimed by national education policy (Ministry of Education Malaysia, 2012). Indirectly, this situation indicates that the number of students who are interested in S&T field is decreasing. These scenarios have raised concerns regarding the ability to shape S&T Culture community in the future, as proposed by The National Philosophy of Science Education (Curriculum Development Centre, 2003). Other than that, this situation needs to be improved in order to give good implication to the national development process (Halim, 2013). Hence, an instrument called Students' Science and Technology Culture Instrument (BST-M) has been designed for this purpose.

Literature Review

The validity and reliability of instruments are very essential in order to ensure the accuracy and consistency of the instruments (Ariffin, Omar, Isa, & Sharif, 2010). The content validity should take precedence, followed by construct validity of the instrument in verifying whether the instrument is valid and reliable (Abdul Aziz, Masodi & Zaharim, 2013, m.s 67). On the other hand, construct validity is crucial to identify the credibility and quality of the instrument. According to Ariffin et al. (2010), reliability is the consistency of a decision on time, while validity refers to the extent to which a test can be tested in line with the test objectives. Therefore, Rasch measurement model is applied in this study to determine the validity and reliability of BST-M instruments.

According to Rasch measurement model, the validity of a questionnaire is identified by referring a positive value of point-measure correlation coefficient (PTMEA Corr). The value of PTMEA Corr shows the item is able to differentiate the ability of the respondent. Furthermore, a negative or zero value indicates a conflict between the responses and the construct. Wright and Masters (1982) stated that infit and outfit mean square (MNSQ) for each item should be within 0.6 to 1.5. On the other hand, Bond and Fox (2015) mentioned that MNSQ should be within 0.6 to 1.4. If MNSQ values are not within these ranges, the items need to be removed or modified. The description of MNSQ value range and measurement implications are shown in Table 1 below.

Table 1: Description of MNSQ range (Linacre, 2002b)

Mean square value (MNSQ)	Measurement Implications
>2.0	Distorts or degrades the measurement system. It is probably caused by only one or two observations.
1.5-2.0	Unproductive for measurement construction, but not degrading.
0.5-1.5	Productive for measurement.
<0.5	Less productive for measurement, but not degrading. It may produce misleading reliability and separation coefficients.

The reliability statistic used in Rasch model is referring to the person and item separation index. Bond and Fox (2015) mentioned that the accepted criterion for strong reliability is it has a value more than 0.8. Meanwhile for the separation index, the higher the separation value, the more precise the measurement is done (Wright & Masters, 1982). However, Linacre (2002) argues that isolation value of more than 2 is good. The study also refers to the quality of measurements stating that the separation index between 3 and 4 as good and more than 5 as excellent (Fisher, 2007).

Methodology

This study was conducted using the developed set of questionnaires. A total of 110 items were contained in this questionnaire in the form of 5-point Likert scale. The questionnaires were distributed to chosen 800 Form Two students (Male = 330, 41.3%; Female = 470, 58.8%) by stratified random sampling from 30 secondary schools in Seremban, Negeri Sembilan. After that, the collected data were analyzed using SPSS and Winstep 3.64.2 software. Construct validity was determined by several factors namely reliability and separation index, item polarity, fit and misfit items.

Research Findings

Item Polarity and Point-measure Correlation

Table 2 shows the PTMEA Corr value for each item is positive, except E3, F15, E2, D3, D2 and E6 items which show non-compliance responses to the constructs. These items need to be reviewed.

Table 2: Correlation Order for Likert scale items

TABLE 26.1 data murid primary800.sav ZOU441WS.TXT Apr 18 9:02 2018
INPUT: 800 PERSON 110 ITEM REPORTED: 800 PERSON 110 ITEM 5 CATS WINSTEPS 3.73

PERSON: REAL SEP.: 4.06 REL.: .94 ... ITEM: REAL SEP.: 13.77 REL.: .99

ITEM STATISTICS: CORRELATION ORDER

|ENTRY TOTAL TOTAL MODEL| INFIT | OUTFIT |PT-MEASURE |EXACT MATCH| |
|NUMBER SCORE COUNT MEASURE S.E. |MNSQ ZSTD|MNSQ ZSTD|CORR. EXP.| OBS% EXP%| ITEM |

43	1819	800	1.57	.04	1.55	9.9	1.68	9.9	-.19	.46	35.5 35.1	E3
68	1531	800	2.00	.04	1.83	9.9	2.00	9.9	-.14	.45	33.4 37.7	F15
42	2324	800	.92	.04	1.78	9.9	1.96	9.9	-.12	.45	24.8 35.3	E2
29	1575	800	1.93	.04	1.63	9.9	1.80	9.9	-.03	.45	33.9 37.0	D3
28	1385	800	2.26	.04	1.80	9.9	2.03	9.9	-.02	.44	32.3 43.5	D2
46	1870	800	1.50	.04	1.82	9.9	1.93	9.9	-.01	.46	30.9 34.9	E6
24	2395	800	.83	.04	1.63	9.9	1.77	9.9	.04	.45	29.4 35.8	C24
27	1506	800	2.04	.04	1.52	9.1	1.61	9.8	.04	.45	38.8 38.2	D1
3	3025	800	-.07	.04	1.25	4.5	1.32	5.7	.13	.39	42.9 45.7	C3
15	2489	800	.71	.04	1.38	7.8	1.48	9.3	.16	.44	29.6 36.6	C15
1	2825	800	.25	.04	1.10	1.9	1.17	3.2	.20	.41	44.1 41.0	C1
17	2729	800	.39	.04	1.27	5.3	1.33	6.2	.24	.42	36.6 39.5	C17
12	3044	800	-.10	.04	1.01	.3	1.08	1.5	.25	.38	48.0 46.1	C12
9	3245	800	-.48	.05	1.13	2.4	1.15	2.7	.26	.35	51.1 48.9	C9
8	3151	800	-.29	.04	1.07	1.4	1.13	2.4	.26	.37	53.3 47.9	C8
36	3078	800	-.16	.04	1.53	8.7	1.58	9.4	.26	.38	41.0 46.8	D10
19	3365	800	-.74	.05	1.18	3.1	1.20	3.5	.27	.33	44.6 49.5	C19
37	2911	800	.12	.04	1.34	6.1	1.41	7.3	.28	.40	40.1 42.8	D11
2	3164	800	-.32	.04	.93	-1.3	.94	-1.1	.29	.37	52.6 48.1	C2
11	3086	800	-.17	.04	.99	-.1	1.01	.3	.29	.38	47.8 46.9	C11
25	2728	800	.39	.04	1.27	5.3	1.30	5.8	.29	.42	39.3 39.5	C25
10	3439	800	-.92	.05	1.22	3.6	1.21	3.5	.30	.32	49.1 50.3	C10
97	2880	800	.17	.04	1.11	2.1	1.12	2.4	.30	.40	42.5 42.2	G16
5	3363	800	-.74	.05	1.05	1.0	1.04	.7	.31	.33	52.1 49.5	C5
30	3072	800	-.15	.04	.93	-1.4	.97	-.6	.31	.38	41.0 46.7	D4
13	3059	800	-.12	.04	1.17	3.1	1.20	3.6	.31	.38	42.5 46.3	C13
32	2962	800	.04	.04	1.37	6.5	1.43	7.4	.32	.39	37.5 44.1	D6
35	3410	800	-.85	.05	1.47	7.3	1.45	7.1	.33	.32	44.5 50.0	D9
33	3298	800	-.59	.05	.96	-.6	.98	-.3	.33	.34	52.3 49.2	D7
4	3334	800	-.67	.05	.99	-.2	.96	-.7	.34	.34	51.5 49.4	C4
21	3184	800	-.35	.04	1.21	3.7	1.21	3.6	.34	.36	42.9 48.3	C21
34	3224	800	-.43	.04	1.10	1.8	1.12	2.1	.35	.36	45.5 48.8	D8
6	3500	800	-1.09	.05	1.10	1.8	1.04	.7	.35	.30	54.0 51.4	C6
20	3089	800	-.18	.04	.92	-1.4	.94	-1.0	.35	.38	48.8 46.9	C20
7	2981	800	.01	.04	.95	-1.0	.96	-.7	.36	.39	47.0 44.6	C7
23	3238	800	-.46	.05	.94	-1.0	.95	-1.0	.37	.35	51.1 48.8	C23
16	3034	800	-.08	.04	.91	-1.7	.92	-1.6	.37	.38	48.9 45.8	C16
48	3123	800	-.24	.04	1.12	2.2	1.12	2.3	.37	.37	44.9 47.4	E8
14	2966	800	.03	.04	.92	-1.5	.93	-1.4	.38	.39	48.9 44.2	C14
40	3435	800	-.91	.05	1.15	2.6	1.11	1.9	.38	.32	51.6 50.1	D14
31	3389	800	-.80	.05	1.09	1.5	1.10	1.7	.38	.33	53.5 49.7	D5
47	3493	800	-1.07	.05	1.24	3.9	1.16	2.8	.38	.30	52.1 51.2	E7
18	3123	800	-.24	.04	.77	-4.6	.77	-4.8	.38	.37	56.0 47.4	C18

39	3182	800	-.35	.04	.95	-.9	.96	-.7	.39	.36	51.6	48.3	D13
57	2612	800	.55	.04	1.01	.3	1.07	1.4	.39	.43	37.6	37.9	F4
22	3297	800	-.59	.05	1.02	.4	.99	-.1	.39	.34	51.8	49.2	C22
62	2542	800	.64	.04	.90	-2.3	.94	-1.3	.40	.44	39.3	37.2	F9
49	3341	800	-.68	.05	1.00	-.1	.96	-.8	.41	.34	50.3	49.4	E9
51	2577	800	.60	.04	1.14	3.1	1.21	4.3	.42	.43	37.6	37.5	E11
38	3247	800	-.48	.05	.82	-3.5	.82	-3.6	.42	.35	55.1	48.9	D12
81	3111	800	-.22	.04	.92	-1.5	.92	-1.5	.43	.37	51.8	47.3	F28
108	3269	800	-.53	.05	1.12	2.0	1.09	1.7	.43	.35	47.6	49.0	G27
67	2749	800	.36	.04	1.00	.0	1.00	.1	.43	.42	41.9	39.8	F14
110	2994	800	-.01	.04	1.24	4.4	1.25	4.6	.44	.39	37.9	44.8	G29
26	3094	800	-.19	.04	.77	-4.7	.76	-4.9	.44	.38	53.4	47.0	C26
76	2647	800	.50	.04	.73	-6.5	.76	-5.6	.44	.43	46.4	38.3	F23
106	3112	800	-.22	.04	.89	-2.2	.89	-2.2	.45	.37	53.5	47.3	G25
66	3218	800	-.42	.04	.89	-2.0	.87	-2.5	.45	.36	55.1	48.7	F13
64	3211	800	-.41	.04	.82	-3.5	.81	-3.7	.45	.36	57.9	48.6	F11
84	3346	800	-.70	.05	.85	-2.7	.82	-3.4	.45	.33	59.3	49.5	G3
80	3141	800	-.27	.04	.93	-1.2	.92	-1.5	.46	.37	52.6	47.7	F27
100	2597	800	.57	.04	.84	-3.8	.85	-3.3	.47	.43	45.9	37.7	G19
50	2799	800	.29	.04	1.02	.5	1.04	.9	.47	.41	42.9	40.6	E10
109	2599	800	.57	.04	.88	-2.8	.89	-2.5	.47	.43	43.0	37.7	G28
91	2985	800	.00	.04	1.15	2.7	1.16	2.9	.47	.39	42.6	44.7	G10
94	2798	800	.29	.04	.86	-3.0	.88	-2.5	.47	.41	43.1	40.6	G13
65	3171	800	-.33	.04	.80	-4.0	.79	-4.3	.48	.36	52.9	48.2	F12
96	2760	800	.34	.04	.91	-1.9	.92	-1.6	.48	.42	45.0	40.0	G15
60	3060	800	-.13	.04	.95	-.9	.96	-.8	.48	.38	52.1	46.4	F7
45	3260	800	-.51	.05	.91	-1.7	.90	-1.9	.48	.35	52.4	48.9	E5
53	2837	800	.23	.04	.96	-.7	.97	-.6	.48	.41	39.9	41.4	E13
99	3053	800	-.11	.04	1.11	2.0	1.14	2.6	.48	.38	46.5	46.2	G18
69	3024	800	-.06	.04	.70	-6.5	.69	-6.6	.48	.39	55.5	45.7	F16
98	3153	800	-.29	.04	.95	-.9	.93	-1.3	.48	.37	48.4	47.9	G17
70	2968	800	.03	.04	.89	-2.2	.90	-2.1	.48	.39	51.6	44.2	F17
101	2723	800	.40	.04	.85	-3.3	.87	-2.7	.49	.42	42.6	39.4	G20
59	2633	800	.52	.04	.85	-3.4	.88	-2.7	.49	.43	40.3	38.1	F6
92	3083	800	-.17	.04	1.03	.7	1.02	.3	.49	.38	46.0	46.8	G11
82	3100	800	-.20	.04	.84	-3.1	.79	-4.3	.50	.37	56.9	47.1	G1
56	2990	800	-.01	.04	.93	-1.4	.93	-1.3	.50	.39	47.9	44.7	F3
63	3225	800	-.43	.04	.80	-3.9	.78	-4.4	.50	.36	56.0	48.8	F10
102	3128	800	-.25	.04	.89	-2.1	.88	-2.4	.50	.37	55.8	47.5	G21
93	3062	800	-.13	.04	.86	-2.9	.85	-3.1	.50	.38	50.9	46.5	G12
41	3286	800	-.56	.05	1.12	2.1	1.05	1.0	.50	.35	49.4	49.1	E1
44	3237	800	-.46	.05	.88	-2.3	.84	-3.0	.51	.35	54.0	48.8	E4
78	3059	800	-.12	.04	.78	-4.6	.78	-4.5	.51	.38	52.5	46.3	F25
105	3187	800	-.36	.04	.77	-4.6	.75	-5.2	.51	.36	55.5	48.3	G24

90	3068	800	-.14	.04	.93	-1.4	.91	-1.7	.52	.38	48.8	46.6	G9
95	2993	800	-.01	.04	.98	-.5	.97	-.6	.52	.39	44.3	44.8	G14
58	2586	800	.58	.04	.81	-4.4	.82	-4.2	.52	.43	40.3	37.6	F5
71	3041	800	-.09	.04	.68	-6.8	.67	-7.2	.53	.38	57.3	46.0	F18
75	2918	800	.11	.04	.73	-6.0	.73	-5.9	.54	.40	51.3	42.9	F22
77	2934	800	.08	.04	.71	-6.3	.73	-5.8	.54	.40	50.1	43.3	F24
61	2793	800	.30	.04	.67	-7.8	.69	-7.2	.54	.41	48.0	40.4	F8
74	2823	800	.25	.04	.81	-4.3	.81	-4.1	.54	.41	45.1	41.0	F21
73	2770	800	.33	.04	.88	-2.6	.88	-2.5	.54	.42	45.0	40.1	F20
86	3188	800	-.36	.04	.80	-4.0	.76	-4.9	.55	.36	57.6	48.3	G5
55	2811	800	.27	.04	.82	-3.8	.85	-3.2	.55	.41	43.4	40.7	F2
107	3248	800	-.48	.05	.79	-4.1	.75	-5.0	.55	.35	57.9	48.9	G26
103	3078	800	-.16	.04	.77	-4.8	.76	-4.9	.55	.38	52.3	46.8	G22
104	3038	800	-.09	.04	.80	-4.0	.77	-4.7	.56	.38	49.5	45.9	G23
85	3094	800	-.19	.04	.81	-3.7	.79	-4.2	.56	.38	50.1	47.0	G4
72	3015	800	-.05	.04	.68	-6.9	.66	-7.3	.56	.39	53.0	45.3	F19
87	3226	800	-.44	.04	.71	-5.9	.69	-6.3	.56	.36	55.6	48.8	G6
89	2893	800	.15	.04	.71	-6.6	.71	-6.5	.57	.40	52.4	42.5	G8
88	2876	800	.17	.04	.67	-7.6	.68	-7.2	.57	.40	47.3	42.1	G7
54	2846	800	.22	.04	.82	-3.8	.82	-3.8	.58	.41	46.5	41.6	F1
52	2913	800	.12	.04	.87	-2.8	.88	-2.5	.58	.40	44.6	42.8	E12
79	3085	800	-.17	.04	.71	-6.2	.68	-6.7	.58	.38	58.1	46.9	F26
83	3034	800	-.08	.04	.67	-7.2	.65	-7.6	.60	.38	53.5	45.8	G2
MEAN	2950.7	800.0	.00	.04	1.01	-.3	1.02	-.2			47.2	44.8	
S.D.	401.5	.0	.61	.00	.26	4.5	.30	4.7			7.1	4.3	

Fit and Misfit Items

Based on Table 2, there were 8 items (E3, F15, E2, D3, D2, E6, C24 and D1) which were unproductive for measurement construction, but not degrading. These items need to be reviewed and modified.

Reliability and Separation Index

According to Table 3, Rasch analysis for Likert scale items shows a high reliability value for *person*, with 0.94 and 0.99 for each item. It indicates that the items are adequate to measure what should be measured. Moreover, the separation index for *person* is 4.06 while the separation index for the item is 13.77.

Table 3: Statistical summary of Likert scale items

TABLE 3.1 data murid primary800.sav ZOU441WS.TXT Apr 18 9:02 2018
INPUT: 800 PERSON 110 ITEM REPORTED: 800 PERSON 110 ITEM 5 CATS
WINSTEPS 3.73

SUMMARY OF 800 MEASURED PERSON

	TOTAL		MODEL		INFIT		OUTFIT	
	SCORE	COUNT	MEASURE	ERROR	MNSQ	ZSTD	MNSQ	ZSTD
MEAN	405.7	110.0	.72	.11	1.04	-.3	1.02	-.4
S.D.	40.3	.0	.54	.01	.52	3.6	.50	3.6
MAX.	528.0	110.0	3.31	.23	3.13	9.9	3.25	9.9
MIN.	287.0	110.0	-.54	.10	.13	-9.9	.14	-9.9

REAL RMSE .13 TRUE SD .52 SEPARATION 4.06 PERSON RELIABILITY .94
MODEL RMSE .11 TRUE SD .53 SEPARATION 4.59 PERSON RELIABILITY .95
S.E. OF PERSON MEAN = .02

PERSON RAW SCORE-TO-MEASURE CORRELATION = .98
CRONBACH ALPHA (KR-20) PERSON RAW SCORE "TEST" RELIABILITY = .95

SUMMARY OF 110 MEASURED ITEM

	TOTAL		MODEL		INFIT		OUTFIT	
	SCORE	COUNT	MEASURE	ERROR	MNSQ	ZSTD	MNSQ	ZSTD
MEAN	2950.7	800.0	.00	.04	1.01	-.3	1.02	-.2
S.D.	401.5	.0	.61	.00	.26	4.5	.30	4.7
MAX.	3500.0	800.0	2.26	.05	1.83	9.9	2.03	9.9
MIN.	1385.0	800.0	-1.09	.04	.67	-7.8	.65	-7.6

REAL RMSE .04 TRUE SD .61 SEPARATION 13.77 ITEM RELIABILITY .99
MODEL RMSE .04 TRUE SD .61 SEPARATION 14.45 ITEM RELIABILITY 1.00
S.E. OF ITEM MEAN = .06

UMEAN=.0000 USCALE=1.0000

By detailing or specifying the reliability and separation index, constructs (B), (E) and (F) are more capable in measuring respondent's capabilities through items in the constructs (Table 4).

Table 4: Reliability and isolation index according to the constructs

Construct	Isolation		Reliability		Measured dimension (%)
	Item	*Person*	Item	*Person*	
Value and Perception on Science and Technology (B)	10.27	2.01	0.99	0.80	24.9
Perception on Science and Technology (C)	22.10	1.12	1.00	0.56	57.2
Scientific Attitude and Common Practice (D)	17.85	1.29	1.00	0.62	44.2
Scientific Mind Habits and Environmental Concerns (E)	12.87	2.78	0.99	0.89	40.1
Personality Traits (F)	7.98	3.15	0.98	0.91	35.9

Conclusion

In conclusion, item analysis is the best method to control the quality of applied measuring tools. Across all constructs, individual separation index are good and the item separation index are excellent. Overall items were found moving towards the constructs except few need to be revised. The next step in this research will be improving the items in this instrument. The data collected using this validated instrument will then be analysed using Hierarchy Linear Modelling (HLM) analysis to determine the relationship between the student's S&T Culture and teacher's productive pedagogy.

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