



Selecting the Top Artisan Woodcraft Projects Using Many Facet Rasch Measurement (MFRM) Model

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Abstract. Once a year, the Geng Seni Kayu Kreatif (GSKK – Creative Woodworkers Group) society conducts a competition for budding craft persons to showcase their ideas and skills. The main objectives were two-fold. First is to check if the selected rubrics are suitable. Second was to rank the woodcraft entries, as fairly as possible. 12 items were identified to measure the woodcraft quality aspects. 20 craft entries were randomly rated by three judges. Rasch MFRM model was used to analyze and rank the items and entries. Item mean is 0.46 and reliability is 0.88. Rater reliability 0.98 indicates raters could reliably separate the entries and items. None of the entries were found misfitting. The scale structure did not exhibit disordered Rasch-Andrich thresholds and had good progressive average measures. Only three entries (E13, E16 and E20) were identified with significant bias among raters, due to significant stricter marks given by one of the raters. Overall, this framework rubric is considered useful for judging woodcraft competitions. It provides non, or very little bias on judgement, and allow less time to judge a competition. However higher-order items need to be improved for future competition, to segregate top entries.

Keywords: Woodworking Project Assessment, MFRM, Rasch Measurement Model.

1 Introduction

Once a year, the GSKK society conducts a competition for budding craft persons to showcase their ideas and skills. Due to high value prizes from various sponsors, the number of entries increases from 30 in last year to 150 this year. As such, the pressure to select the best entries was overwhelming. In the past, there were issues on fairness in scoring mechanism to select and rank the showcased crafts. The main objectives for this assessment were two-fold. First is to check if the selected rubrics are suitable. Second was to rank the woodcraft entries, as fairly as possible.

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2 Methods

Due to time constraint in preparing the assessment rubrics for woodworking craft quality aspects, we found two suitable frameworks from Canadian Woodworking Assessment [1] and Nebraska Department of Education Woods Project Rubric [2]. Upon discussions, 12 aspects and five levels of conformance were agreed upon. The aspects are Novelty, Creativity, Functions/usefulness, Size of product, Chamfers and/or Routed Edge, Square Cuts, Special Joinery, Fasteners Set, Sanded Surfaces, Deformation (Crack, Checks, Missing Knots), Hammer Tracks & Dents, and Finishing.

Meanwhile, the 5 levels of conformance define the levels for each aspect. This shall be used as guidelines when giving the scoring for each craft presented. The framework or rubric is depicted in Table 1 below:

Table 1.Craft Assessment Rubric

		Item Abbrev.	Level 0	Level 1	Level 2	Level 3	Level 4	Weightage
Novelty & creativity	Novelty	N1N	Product is available cheaply in market	Product is available in market, but not cheap to buy.	similar product exists but this product is an enhancement .	similar product exists but this product is an extension (improvement)	No one has done this before	1
	Creativity	N2C	100% copy from existing product	Copy with slight modification	Copy with improvements	Copy with improvements and with aesthetic values, including good joineries	New trend and system (new material/construction)	2
	Functions/usefulness	N3F	The project does not work	The project has ONLY 1 uses but does not work 100%	The project has 1 operable functions.	The project has 2 operations or functions.	The project has 3 or more functions/uses	1
Construction	Size of product meet criteria	C4S	ALL length, width, depth exceed 1 feet.	ANY Two of length, width, depth exceed 1 feet.	ANY one of length, width, depth exceeds 1 feet.	All measures meet 1 feet dimension	Compact design	4
	Chamfers and/or Routed Edge	C5C	Chamfers are a mess	ONLY 1 chamfer is of proper size (1/8") and is parallel to the edge and/or there are 3 or more tapers.	ONLY 2 chamfers are of proper size (1/8") and are parallel to the edge or there are 2 tapers.	ONLY 3 chamfers are of proper size (1/8") and are parallel to the edge or there is 1 taper.	ALL chamfers are parallel to the edge and are of proper size (1/8"), and there are NO tapers.	1
	Square Cuts	C6S	NO corners have tight matching fit and are crisp, not rounded.	FEW corners have tight matching fit and are crisp, not rounded.	SOME cuts are square with crisp, not rounded, corners.	MOST cuts are square with crisp, not rounded, corners.	ALL cuts are square with crisp, not rounded, corners.	1
	Special Joinery (Dovetail, Lap Joints, etc.)	C7J	NO joints have tight matching fit with smooth surface transition.	FEW joints have tight matching fit with smooth surface transition.	SOME joints have tight matching fit with smooth surface transition.	MOST joints have tight matching fit with smooth surface transition.	ALL joints have tight matching fit with smooth surface transition.	1
	Fasteners Set Properly	C8F	MORE THAN 3 fastener heads are protruding or flush with the surface of wood.	NO MORE THAN 3 fastener heads are protruding or flush with the surface of wood.	NO MORE THAN 2 fastener heads are protruding or flush with the surface of wood.	NO MORE THAN 1 fastener head is protruding or flush with the surface of wood.	ALL fastener heads are set no more than 1/16" below surface of wood with no points protruding.	1
Finishing	Sanded Surfaces	F9S	There are 1 or more rough surfaces and/or 2 or more rounded corners and/or 3 or more sharp edges, including holes.	There is 1 rough surfaces and/or 2 rounded corners and/or 3 sharp edges, including holes.	NO surfaces are rough, but there is 1 rounded corner or 1-2 sharp edges, including holes	NO surfaces are rough, NO surfaces have rounded corners, but there is 1 sharp/rough edge or hole.	NO surfaces are rough, NO surfaces have rounded corners, and NO surfaces have sharp/ rough edges or holes.	1
	Crack, Checks, Missing Knots	F10C	There are MORE THAN 3 cracks, checks, missing knots, or other natural defects	There are Only 3 cracks, checks, missing knots, or other natural defects	There are ONLY 2 cracks, checks, missing knots, or other natural defects.	There is ONLY 1 crack, check, missing knot, or other natural defect.	There are NO cracks, checks, missing knots, or other natural defects.	1
	Hammer Tracks and Dents	F11H	There are many hammer tracks and/or many dents.	There are 2 or more hammer tracks and/or 2 or more dents.	There is 1 hammer track and NO MORE THAN 1 dent.	There are NO hammer tracks and NO MORE THAN 1 dent.	There are NO hammer tracks and NO dents	1
	Finish	F12F	The finish is not smooth and is full of blotches brush marks or imperfections	The finish is not very smooth and has many blotches, brush marks or imperfections	The finish is somewhat smooth and has some blotches, brush marks or imperfections	The finish is mostly smooth and has few blotches, brush marks or imperfections	The finish is smooth and has no blotches, brush marks or imperfections	2

In addition, we identified three items as critical and these were assigned higher weightage. These items are Size of Product, Creativity and Finishing. The size of product was set at the beginning of competition as the main parameter.

150 initial entries were received by the committee. These were narrowed down to 20 entries based the entry requirements and public ‘likes’ in Facebook. These final 20 entries were rated by three judges who are well-known in the community. Since judging takes around 10 minutes per entry, to save time, each judge shall only rate 10

entries, with some entries being rated by 2 or more judges. The entry numbers were first randomized to avoid bias on positions, before being assigned to the 3 judges, per Table 2 below.

Table 2. Random Entry Assignment to Raters

Original entries	Random value	PR	SI	Zali
		Rater 1	Rater 2	Rater 3
1	E19	19		
2	E6	6		
3	E15	15		
4	E9	9		
5	E8	8	8	
6	E16	16	16	
7	E10	10	10	
8	E20	20		20
9	E13		13	13
10	E11	11		11
11	E4		4	
12	E17		17	
13	E5		5	
14	E12		12	12
15	E2		2	2
16	E1		1	1
17	E7		7	7
18	E18			18
19	E14			14
20	E3			3

Rasch MFRM model using Minifac 3.83.6 [3] was used to analyze and rank the items and entries. The judging exercise was aired live via Facebook for participants to observe.

3 Analyses on Instrument

Person(entry) mean is 0.46 and reliability is 0.88 indicate, on overall, entries were scored highly, and samples are able to separate items reliably, up to 4 strata ($G=2.73$). 2 entries were found misfitting (E5 and E13) with MNSQ greater than 1.6. But since this is an assessment exercise, no entry is removed or changed. Entry E10 has the highest measure of 2.5 logit corresponding to raw score of 114. Meanwhile Entry E3 was scored the lowest with -1.42 logit.

Table 3. Entries Measures

Total Score	Total Count	Obsvd Average	Fair(M) Average	+ Measure	Model S.E.	Infit MnSq ZStd	Outfit MnSq ZStd	Estim. Discrm	Correlation PtMea PtExp	Nu Entries
114	34	3.35	3.49	2.50	.32	.75 -1.0	.67 -1.2	1.39	.64 .49	10 E10
112	34	3.29	3.43	2.30	.31	.99 .0	.85 -4	1.18	.53 .50	19 E19
106	34	3.12	3.25	1.74	.30	.71 -1.3	.62 -1.5	1.35	.71 .52	15 E15
104	34	3.06	3.18	1.55	.30	.74 -1.1	.79 -7	1.14	.73 .52	6 E6
113	34	3.32	3.11	1.36	.30	1.01 .1	.96 .0	.99	-.01 .14	11 E11
97	34	2.85	2.96	.91	.31	1.43 1.5	1.58 1.8	.38	.24 .51	9 E9
96	34	2.82	2.92	.81	.31	.81 -7	.62 -1.4	1.32	.42 .51	8 E8
105	34	3.09	2.88	.68	.29	1.54 2.1	2.21 3.6	-.51	.17 .15	13 E13
94	34	2.76	2.87	.66	.31	.45 -2.6	.38 -2.8	1.51	.40 .49	2 E2
102	34	3.00	2.80	.43	.29	1.21 .9	.92 -2	.98	.48 .15	20 E20
50	17	2.94	2.76	.30	.41	.53 -1.6	.43 -1.6	1.44	.32 .16	14 E14
49	17	2.88	2.70	.14	.41	1.17 .6	.86 -2	1.09	.59 .17	12 E12
88	34	2.59	2.67	.04	.32	1.00 .0	1.12 .4	.79	.03 .48	16 E16
39	17	2.29	2.66	-.01	.50	.38 -1.7	.37 -1.8	1.52	.10 .24	17 E17
87	34	2.56	2.65	-.02	.32	1.05 .2	.82 -5	1.13	.46 .47	1 E1
48	17	2.82	2.65	-.03	.41	1.19 .6	.87 -1	1.09	.61 .17	18 E18
86	34	2.53	2.62	-.12	.32	.98 .0	.88 -3	1.03	.37 .47	7 E7
42	17	2.47	2.32	-1.27	.47	.95 .0	.90 .0	1.04	.56 .22	4 E4
42	17	2.47	2.32	-1.27	.47	1.58 1.3	2.25 2.2	.31	.69 .22	5 E5
41	17	2.41	2.29	-1.42	.48	.80 -3	.72 -5	1.18	.16 .22	3 E3
80.7	28.1	2.83	2.83	.46	.36	.96 -.1	.94 -.3		.41	Mean (Count: 20)
27.8	8.1	.31	.33	1.06	.07	.32 1.2	.50 1.5		.23	S.D. (Population)
28.5	8.3	.32	.34	1.09	.07	.33 1.2	.52 1.5		.23	S.D. (Sample)

Model, Populn: RMSE .36 Adj (True) S.D. .99 Separation 2.73 Strata 3.97 Reliability .88
 Model, Sample: RMSE .36 Adj (True) S.D. 1.02 Separation 2.81 Strata 4.08 Reliability .89
 Model, Fixed (all same) chi-squared: 162.9 d.f.: 19 significance (probability): .00
 Model, Random (normal) chi-squared: 17.0 d.f.: 18 significance (probability): .52

Rater mean is 0.0 with reliability 0.98 indicates items and entries are sufficient to separate raters. Rater ‘Pak Rimau’ was evidently stricter than the other 2 raters (Zali & SI - Shairul Iman). This was evident with Pak Rimau’s measure at 1.3 logit compared to -0.62 logit and -0.68 logit for Zali and Shairul Iman, respectively.

Table 4. Raters Measures

Total Score	Total Count	Obsvd Average	Fair(M) Average	- Measure	Model S.E.	Infit MnSq ZStd	Outfit MnSq ZStd	Estim. Discrm	Correlation PtMea PtExp	Exact Agree. Obs % Exp %	N Raters
478	187	2.56	2.43	1.30	.14	.62 -3.8	.53 -4.3	1.33	.36 .46	42.4 41.1	1 PakRimau
496	170	2.92	3.02	-.62	.13	1.03 .2	.86 -1.1	1.07	.46 .37	52.0 47.8	3 Zali
641	204	3.14	3.04	-.68	.13	1.23 2.2	1.40 3.3	.53	.58 .55	41.8 42.7	2 SI
538.3	187.0	2.87	2.83	.00	.13	.96 -.4	.93 -.7		.47		Mean (Count: 3)
73.0	13.9	.24	.28	.92	.00	.25 2.5	.36 3.1		.09		S.D. (Population)
89.4	17.0	.30	.35	1.13	.01	.31 3.1	.44 3.8		.11		S.D. (Sample)

Model, Populn: RMSE .13 Adj (True) S.D. .91 Separation 6.91 Strata 9.54 Reliability (not inter-rater) .98
 Model, Sample: RMSE .13 Adj (True) S.D. 1.12 Separation 8.49 Strata 11.65 Reliability (not inter-rater) .99
 Model, Fixed (all same) chi-squared: 140.4 d.f.: 2 significance (probability): .00
 Model, Random (normal) chi-squared: 2.0 d.f.: 1 significance (probability): .16
 Inter-Rater agreement opportunities: 221 Exact agreements: 98 = 44.3% Expected: 95.6 = 43.3%

Based on Table 5, item mean is 0.0 and reliability is 0.52 (G=1.03) indicating, on overall, items are not able to separate entries reliably. This is quite normal for this type of assessment for crafts since most of them are about the same level. None of the items are considered misfitting, which is good. The range of measures for items goes from -0.62 logit to 0.61 logit, which is quite narrow. In fact, compared to entries’ measures, there are many entries that are above 0.61 logit. This means, the items are

not sufficient to separate entries at higher level. Further evidence are depicted in Wright Map (Fig. 1) where only about 50% of persons are able to ‘measure’ items.

Table 5. Items Measures

Total Score	Total Count	Obsvd Average	Fair(M) Average	Measure	Model S.E.	Infit MnSq ZStd	Outfit MnSq ZStd	Estim. Discrm	Correlation PtMea PtExp	Nu Traits			
200	66	3.03	2.91	.61	.19	.91	-.5	.85	-.7	1.12	.67	.65	2 N2C
81	33	2.45	2.32	.58	.29	.64	-1.6	.59	-1.8	1.43	.61	.60	10 F10C
202	66	3.06	3.01	.40	.26	1.23	1.2	1.23	1.2	.73	.31	.50	12 F12F
404	132	3.06	3.02	.25	.23	.90	-.6	.83	-.8	1.05	.46	.41	4 C4S
88	33	2.67	2.53	.01	.28	1.31	1.2	1.36	1.3	.62	.76	.62	3 N3F
88	33	2.67	2.53	.01	.28	.66	-1.6	.67	-1.4	1.30	.57	.62	11 F11C
89	33	2.70	2.57	-.07	.28	.78	-.9	.72	-1.1	1.28	.61	.62	8 C8S
90	33	2.73	2.60	-.15	.28	1.33	1.3	1.36	1.4	.30	.44	.62	1 N1N
90	33	2.73	2.60	-.15	.28	1.10	.4	1.09	.4	.99	.76	.62	7 C7J
91	33	2.76	2.63	-.23	.28	1.23	.9	1.15	.6	.87	.54	.63	9 F9S
96	33	2.91	2.81	-.62	.28	.95	-.1	.90	-.3	1.11	.61	.63	5 C5C
96	33	2.91	2.81	-.62	.28	.77	-1.0	.74	-1.1	1.35	.70	.63	6 C6S
134.6	46.8	2.81	2.70	.00	.27	.98	-.1	.96	-.2		.59		Mean (Count: 12)
91.1	28.4	.18	.21	.39	.03	.24	1.1	.26	1.1		.13		S.D. (Population)
95.1	29.7	.19	.22	.41	.03	.25	1.1	.27	1.2		.13		S.D. (Sample)

Model, Popul: RMSE .27 Adj (True) S.D. .28 Separation 1.03 Strata 1.71 Reliability .52
 Model, Sample: RMSE .27 Adj (True) S.D. .30 Separation 1.12 Strata 1.83 Reliability .56
 Model, Fixed (all same) chi-squared: 28.0 d.f.: 11 significance (probability): .00
 Model, Random (normal) chi-squared: 8.0 d.f.: 10 significance (probability): .63

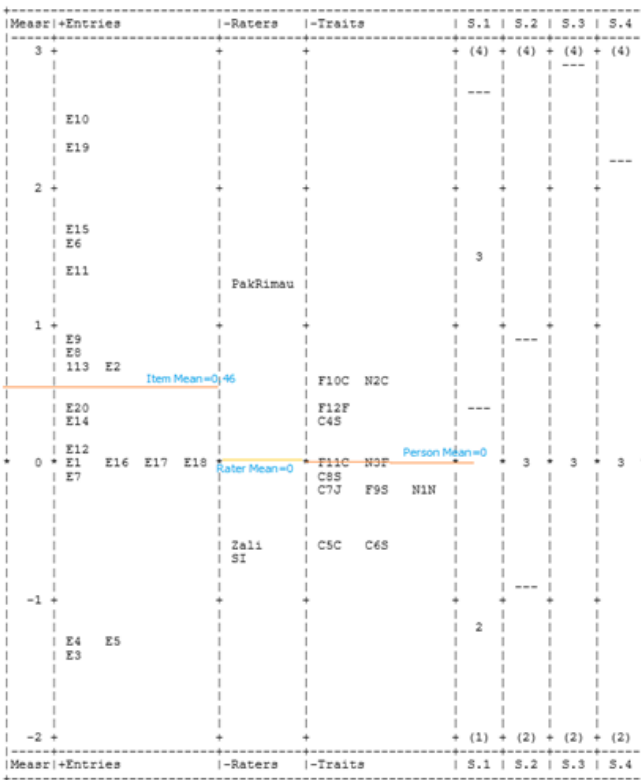


Fig.1. Wright Map

Categories used in the instrument are Level 0, Level 1, Level 2, Level 3 and Level 4, where Level 4 indicates the highest conformance to the aspects being judged. Level 0 was not used at all. Looking at Table 6, all categories are functioning well. No disordered average observed, and all have good threshold differences.

Table 6. Category Functioning

Model = ?B, ?B, ?, R5														
DATA				QUALITY CONTROL			RASCH-ANDRICH		EXPECTATION		MOST		RASCH- THURSTONE	
Category	Counts	Cum.		Avg	Exp.	OUIFIT	Thresholds	Measure	at	PROBABLE	THURSTONE	PEAK		
Score	Total	Used	%	Meas	Meas	MnSq	Measure	S.E.	(Category	-0.5	from	Thresholds	Prob	
1	9	9	3%	3%	-.53	-.80	1.1		(-4.07)		low	low	100%	
2	118	118	40%	43%	.02	.05	1.0	-2.99	.35	-1.19	-3.04	-2.99	-3.01	
3	116	116	39%	82%	1.08	1.13	1.0	.62	.14	1.51	.37	.62	.49	
4	54	54	18%	100%	2.17	2.06	.8	2.37	.17	(3.57)	2.69	2.37	2.50	
(Mean)										(Modal)		(Median)		

In terms of entry bias, per Table 7, Only one entry was deemed having significant bias. Entry E13 was scored 47 but expected score was 52.69. This was undervalued by rater SI, but overvalued by rater Zali (58). As we recall, Entry E13 was identified as misfitting earlier. Explained by the both infit/outfit MNSQ in Bias.

Table 7. Entry Bias

Woodworking assessment by different Raters 24/11/2021 9:08:46 PM
 Table 13.1.2 Bias/Interaction Report (arranged by FN).
 Bias/Interaction: 1. Entries, 2. Raters (higher score = higher bias measure)

Observed Score	Expected Score	Observed Count	Obs-Exp Average	Bias+ Size	Model S.E.	t	d.f.	Prob.	Infit MnSq	Outfit MnSq	Entries Sq Nu	Raters meas+ N	Raters meas-	
47	52.69	17	-.331	-.95	.42	-2.27	16	.0376	2.4	3.9	19 13	E13	.68 2 SI	-.68
46	50.83	17	-.281	-.83	.43	-1.93	16	.0711	1.3	1.0	33 20	E20	.43 3 Zali	-.62
45	48.80	17	-.221	-.68	.44	-1.55	16	.1410	.9	1.0	21 16	E16	.04 2 SI	-.68
44	47.19	17	-.191	-.60	.45	-1.33	16	.2008	.7	.6	8 15	E15	1.74 1 PakRimau	1.30
49	51.71	17	-.161	-.45	.41	-1.09	16	.2903	.7	.5	7 10	E10	2.50 1 PakRimau	1.30
44	46.17	17	-.131	-.42	.45	-.93	16	.3687	.4	.3	3 6	E6	1.55 1 PakRimau	1.30
...														
65	62.23	17	.161	.87	.64	1.36	16	.1934	1.1	1.1	17 10	E10	2.50 2 SI	-.68
62	58.74	17	.191	.70	.50	1.42	16	.1757	.7	.7	20 15	E15	1.74 2 SI	-.68
56	51.19	17	.281	.81	.42	1.93	16	.0716	.6	.5	23 20	E20	.43 2 SI	-.68
43	39.16	17	.231	.89	.46	1.94	16	.0703	.8	.7	9 16	E16	.04 1 PakRimau	1.30
58	52.33	17	.331	.98	.43	2.26	16	.0379	.9	.8	30 13	E13	.68 3 Zali	-.62
48.9	48.93	17.0	.001	.03	.45	.03			.9	.9	Mean (Count: 33)			
7.1	6.58	.0	.151	.47	.05	1.04			.5	.7	S.D. (Population)			
7.2	6.69	.0	.151	.48	.05	1.06			.5	.8	S.D. (Sample)			

Fixed (all = 0) chi-squared: 36.0 d.f.: 33 significance (probability): .33

For Raters, per Table 8, Raters' bias for E20, E16 and E13 are significant at $p < 0.05$. Looking back at the score sheet, there were noticeable scoring differences between raters. Perhaps more training for raters. Pak Rimau appears more strict than the other 2 raters did.

Table 8. Raters Bias

Table 14.1.2.2 Bias/Interaction Pairwise Report (arranged by FN).

Bias/Interaction: 1. Entries, 2. Raters

Target Nu Ent	Target+ Measr	S.E.	Obs-Exp Average	Context N Raters	Target+ Measr	S.E.	Obs-Exp Average	Context N Raters	Target+ Contrast	Joint S.E.	Rasch-Welch t	d.f.	Prob.
20 E20	1.24	.42	.28	2 SI	-.40	.43	-.28	3 Zali	1.63	.60	2.73	31	.0103
16 E16	.93	.46	.23	1 PakRimau	-.64	.44	-.22	2 SI	1.57	.64	2.47	31	.0191
9 E9	1.34	.44	.12	1 PakRimau	.57	.41	-.12	2 SI	.77	.60	1.29	31	.2076
2 E2	.93	.46	.07	1 PakRimau	.46	.41	-.07	3 Zali	.47	.61	.76	31	.4504
7 E7	.00	.50	.03	1 PakRimau	-.22	.42	-.03	3 Zali	.21	.65	.33	31	.7458
8 E8	.93	.46	.03	1 PakRimau	.73	.41	-.03	2 SI	.20	.62	.32	31	.7480
1 E1	.00	.50	.00	1 PakRimau	-.04	.41	-.01	3 Zali	.04	.65	.06	30	.9526
19 E19	2.22	.41	-.03	1 PakRimau	2.44	.50	.03	2 SI	-.23	.64	-.35	30	.7280
11 E11	1.07	.41	-.10	2 SI	1.66	.43	.10	3 Zali	-.59	.60	-.99	31	.3303
6 E6	1.14	.45	-.13	1 PakRimau	1.99	.46	.13	2 SI	-.85	.64	-1.33	31	.1927
10 E10	2.05	.41	-.16	1 PakRimau	3.36	.64	.16	2 SI	-1.32	.76	-1.73	27	.0944
15 E15	1.14	.45	-.19	1 PakRimau	2.44	.50	.19	2 SI	-1.30	.67	-1.95	31	.0608
13 E13	-.27	.42	-.33	2 SI	1.66	.43	.33	3 Zali	-1.93	.60	-3.20	31	.0031

4 Results of competition

The ranking of entries is listed based on entry measures in logit. The winner of the competition, listed in Table 9, is entry E10. The entry is a beautiful box made from rare arangbunga, pine and nyatoh (Figure 2) brought home Makita power tools worth RM1,500. On post discussion, all judges agree on the ranking of entries. No objection were received from audience.

Table 9.Entry Measures and Rank

rank	score	entry	real entry no.
1	2.5	E10	7
2	2.3	E19	1
3	1.74	E15	3
4	1.55	E6	2
5	1.36	E11	10
6	0.91	E9	4
7	0.81	E8	5
8	0.68	E13	9
9	0.66	E2	15
10	0.43	E20	8
11	0.3	E14	19
12	0.14	E12	14
13	0.04	E16	6
14	-0.01	E17	12
15	-0.02	E1	16
16	-0.03	E18	18
17	-0.12	E7	17
18	-1.27	E4	11
19	-1.27	E5	13
20	-1.42	E3	20



Fig. 2. Winning Entry

5 Conclusion

This framework rubric is considered useful for judging woodcraft competitions. It provides non, or very little bias on judgement, and allow less time to judge a competition. However higher-order items need to be improved for future competition, to segregate top entries.

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