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Validity and Reliability of the Design and Technology Instrument

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Abstract---*This study was conducted to generate empirical evidence on the validity and reliability of the items for new instrument in Design and Technology (D&T) subject. The measurement of RBT subject instruments that had been prepared consisted of 41 skill items is distributed to 100 teachers. Cluster random sampling and simple random sampling methods were utilized in selecting a total of 100 secondary school teachers all over Peninsular Malaysia who teach the subject of D&T. Two stages of processes were used to identify and validate constructs. The first stage involved the identification of constructs using exploratory factor analysis method and the second stage was construct validation stage using the Rasch measurement model. The purpose of the establishment of this instrument is to measure the four main constructs of this study, which is; (1) Designing skill; (2) Sketching skill; (3) Applying Technology skill; (4) Designing in marketing skill. At the end of the analysis, it is found that there is a total of 13 polytomous items that were discarded because they did not fulfil the inspection criteria specified in accordance to the Rasch Model. The final instrument recorded a total of 27 polytomous items subsequently that can only be used to measure the four constructs of the study. In conclusion, this study has established valid constructs for development of instruments for measuring design and technology subject.*

Keywords---*Design and Technology, D&T, Validity, Reliability, Rasch Measurement Model*

I. INTRODUCTION

The era of industrial revolution 4.0 (IR 4.0) with the advent of new technology has undeniable impacts on teaching and learning design and technology (D&T) education. Students nowadays are empowered with the knowledge, skills and value related to technical and vocational fields, and next will be pursued at the secondary school level. The industry era 4.0 is now at the threshold where very much compelled to provide job expertise to cope with today's changing work environment. D&T was introduced to students with the kind of advantageous experiences that will help them throughout life. With a changing curriculum, the subject of D&T was developed in 2014 which been introduced in primary school while secondary school was in 2017 is aimed to expand the notion of design and applied technology, with its gendered and set pieces to include planning and thinking. In order to teach D&T subject, teachers must possess a mixtures of knowledge, skills, attitudes and values. Skills are the practical capabilities that can be performed (Jones,2016). Practices concerning the recycling of used materials is also important and needs to be nurtured towards the students, especially in the subjects of D&T. This distinction is important in D&T as teachers

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must possess both knowledge of technology and the practical skills to use these technologies. Jones (2016) in his study showed that teachers' lack of compatible background in subject knowledge and were evident in the teaching of projects without securing technology content precisely. In consonance with the study carried out by Huei, Kamis and Rus (2019); Kamis, Ahmad Puad, Mohamed, Che'Rus, Bujeng, Shamwil, dan Bidiastutiu(2018); Alwi, Kamis and Ismail (2018), development of D&T measurement instruments is prerequisite so that it can measure the mastery level of D&T content knowledge among teachers who teach the subject. Martin (2008), suggested that execution of further studies are required for the great development of the skills and knowledge of D&T teachers. There are a few researches that have developed and validated competency instruments that measure the aspects of skills and knowledge using Rasch Model Measurement (Arasinah et al., 2018;Kamis et al., 2017;Yasin et al., 2015).This study aims to test the validity and reliability of Design and technology instruments on for teachers at the secondary school using Rasch analysis.

II. RESEARCH METHOD

This paper be focused on the validation stage of the instrument development process which involved a survey on 100 D&T secondary teachers in Malaysia. The quantitative research involved two stage of processes to identify and validate the constructs. The first stage involved identification of constructs through literature reviews and supported by Exploratory Factor Analysis (EFA). The EFA indicated the presence of constructs from skill dimension. The validation process was taken further using the Rasch Measurement Model for polytomous data (skill items) aided by Winstep software, version 3.72. Rasch model with the application of WINSTEPS version 3.72 was used to analyse the data as well as to test the validity and reliability of the instrument. The Rasch measurement model incorporated a method in ordering person according to their ability and sorting items according to their difficulties (Bond and Fox, 2015). According to Bond and Fox (2015), the criteria in Table 1.0 below is used as the benchmarks to determine the validity of the instrument. Knowledge items were dichotomous scale and skill items were polytomous likert scale. Item compatibility was started with Mean Square (MNSQ) in which value not exceeding Mean Infit (MNSQ) with + / (-) S.D). Misfit and Outlier can be detected by seeing ZSTD values larger or out of limit t +/- 2 logit (Azrilah et al., 2015). The MNSQ range should be at the range of 0.70 logits up to 1.30 logits (Bond and Fox 2015) for dichotomous scale items (knowledge items). The MNSQ range should be at the range of 0.60 logits up to 1.40 logits (Bond and Fox, 2015) for polytomous or likert scale items (skill, attitude and value items). The ZSTD value is the accepted value in between -2.0 to 2.0 (Bond and Fox, 2015), and according to Linacre (2004), the ZSTD value can be ignored if MNSQ has been accepted.

Table 1: Summary of item validity and reliability using Rasch Model.

Criteria Statistical Info Results Item Validity	Value	Reference
Item Fit Total Mean Square infit and outfit polytomous (Item Misfit)	0.60-1.40 logits	Bond & Fox 2015
Person Reliability Value	> 0.8	Bond & Fox 2015
Item Reliability Value	> 0.8	Bond & Fox 2015
Item Polarity PTMEA CORR	Positif, > 0	Bond & Fox 2015
Separation (SE) All items show	≥ 2.0	Linacre 2007

Unidimensionality - Value Principal Component Analysis of Residual (PCA)	Minimun 20%	Conrad, Dennis & Funk (2012)
Unidimensionality - Value of disturbance or variance level is not clear	Maximum 15%	Azrilah et al. (2015)

The Instruments had been constructed with 41 items which comprised of four main constructs, namely (1) Designing skill; (2) Sketching skill; (3) Applying Technology skill; and (4) Designing in marketing skill.

Table 2: Subcontruct Number of Items

Subconstruct	Code Item	Total Item
Designing Skill	K6C1-K6C10	10 items
Sketching Skill	K7C1-K7C17	17 items
Applying Technology Skill	K8C1-K8C8	8 items
Designing in marketing Skill	K9C1-K9C6	6 items

III. RESULTS AND DISCUSSION

Data were analysed using the Rasch measurement model. Skill items was in polytomous form with the five score Likert scale designed based on category of: 1) not competent, 2) less competent, 3) moderately competent, 4) competent, 5) very competent.

Reliability and Item Separation

The process of analysing data was using Rasch measurement model to test the reliability of the instrument as shown in Table I. Table I shows the reliability index for the interpretation of skills (41 items) was about 0.85. The reliability of the respondents for the assessment of skills was 0.91. This data indicated that these instruments are consistent and stable if administered in other samples that have the same and nearly similar features. The reliability index was parallel with instruments as suggested by Fisher (2007), and DeVillis (2012), which stated that the respondents and item reliability index > 0.8 is an acceptably good and high index. Meanwhile, the index of item separation skills items was 2.40, which were moderately good statistically. Respondents separation index (person separation) for skill items was 3.32, which showed the ability of the respondents were at a good level. The findings also were in concordance with the recommendations initiated by Bond and Fox (2015), and Linacre (2004), where the value that shows a good index separation is a value that is greater or more than the value of 2.0. Meanwhile, Fisher (2007) also suggested the value of individual and items separation between 2 to 3 is moderately good and more than 5 is excellent.

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Table 3: Summary of the Reliability and Separation of the Items Using Rasch Model

Construct	Results			
	Item reliability	Person reliability	Item separation	Person separation
Skill	0.85	0.91	2.40	3.23
Acceptance lever	>.80 Fisher, 2007; DeVillis, 2012		>2.0 Bond & Fox, 2015; Linacre, 2004	

Polarity Item by PTMEA CORR Value

The polarity of the items shown by the PTMEA CORR value as mentioned by Bond and Fox (2015) that PTMEA CORR negative value indicates the item is not parallel and should be eliminated. MeanWhile, if the value is positive (+), then it indicates the respective items can achieve its goals by deliberating the construct that needs to be measured. Based on Table 1.3 below, a total of 41 skill items have strong positive PTMEA CORR values between 0.32 to 0.81. This means that all skill items in this construct were parallel with the construct to measure the intended construct.

Table 4: Point Measure Correlation (PMEA CORR) Value (Skill)

Entry Number	Point Measure Corr.	Item	Entry Number	Point Measure Corr.	Item	Entry Number	Point Measure Corr.	Item
2	.33	K6C2	22	.64	K7C9	20	.75	K7C7
3	.34	K6C3	13	.70	K6C13	21	.68	K7C8
1	.32	K6C1	39	.81	K8C5	26	.71	K7C13
50	.46	K9C5	37	.72	K8C3	14	.67	K7C1
51	.33	K9C6	38	.76	K8C4	24	.71	K7C11
49	.45	K9C4	11	.67	K6C11	25	.71	K7C12
52	.33	K9C7	42	.72	K8C8	36	.67	K8C2
5	.65	K6C5	10	.59	K6C10	29	.65	K7C16
4	.62	K6C4	43	.75	K8C9	28	.78	K7C15
19	.50	K7C6	46	.55	K9C1	33	.72	K7C20
48	.53	K9C3	17	.70	K7C4	35	.67	K8C1
6	.61	K6C6	18	.73	K7C5	27	.81	K7C14
12	.66	K6C12	40	.70	K8C6	34	.71	K7C21
15	.64	K7C2	9	.33	K6C9	23	.72	K7C10
7	.57	K6C7	44	.73	K8C10	32	.68	K7C19
45	.76	K8C11	16	.68	K7C3	31	.71	K7C18
47	.43	K9C2	41	.78	K8C7	30	.67	K7C17
8	.66	K6C8						

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Item Fit in Measuring the Constructs

Item fit measured the constructs through the infit and outfit Mean Square (MNSQ). According to Bond and Fox (2015), the outfit and infit MNSQ should be in the range 0.60 to 1.40 logits for polytomous items to ensure that the items are suitable for measuring the constructs. However, the outfit index MNSQ noteworthy in advance if compared to infit MNSQ for determining congruity of items that measure a construct or latent variable (MohdKashfi, 2011). If the infit or outfit is 1.40 logit (polytomous), then it gives the meaning of confusing item. If the MNSQ value is less than 0.60 logit (polytomous), it shows that the item is too easily anticipated by the respondents (Linacre, 2007). In addition, the outfit and infit ZSTD value should also be within -2.00 to +2.00 (Bond & Fox, 2015). Nevertheless, if the outfit and infit MNSQ is being accepted, then the ZSTD index can be ignored (Linacre, 2007).

Therefore, if this condition is not satisfied, then the item should be either removed or refined. The Table 1.4 below shows the misfit order featuring items having the largest MNSQ and the smallest MNSQ analysis statistics: misfit order. Based on Table 5 below, it found that 10 items from skill items were not in the specified range and it should be revised or refined.

Table 5: Item Fit Based on MNSQ Value

constru k	Measure	Mode l SE	Infit		0utfit		PTME A CORR	Item
			MNS Q	ZST D	MNS Q	ZST D		
Skill	0.76	0.22	1.43	2.7	1.39	2.2	0.43	K6C3
	0.76	0.22	1.43	2.7	1.39	2.2	0.43	K6C1
	-0.20	0.23	0.63	-3.0	0.54	-3.2	0.80	0
	1.95	0.21	1.57	3.6	1.91	4.3	0.32	K6C4
	-0.50	0.24	1.52	2.7	1.71	2.8	0.66	K7C1
	0.92	0.30	0.57	-2.6	0.32	-2.8	0.89	6
	0.48	0.30	0.59	-2.4	0.34	-2.4	0.88	K7C1
	0.39	0.30	0.54	-2.9	0.32	-2.5	0.88	5
	0.21	0.30	0.59	-2.5	0.35	-2.2	0.89	K9C3
	-2.00	0.28	2.10	5.3	3.66	5.4	0.03	K9C4
								K9C5
								K9C2
								K9C1

Unidimensionality

Residual Principal Component Analysis (PCA) is used in Rasch's analysis to ensure the consistency of the dimensions of the instrument, the technique used is the Residual Variant Standard (Azrilah et al., 2015). Researcher referred to two criterias which intesting the unidimensionality of an instrument namely the value of Principal Component Analysis of Residual (PCA) and (ii) the level of distortion of items or unexplained variance 1st contrast

(Azrilah et al., 2015). According to Fisher (2007), the good PCA value is at least 20% and more than 40% and the unexplained variance 1^{st} contrast is 15% maximum (Azrilah et al., 2015). Local independence is a value referring to the individual abilities of an item that not related to another item in the same construct. Values that meet local independence requirements are less than 0.7 (Linacre, 2007).

Table 6 below represents the findings of Principal Component Analysis (PCA) based on variance explained by measure for content knowledge. The PCA value showed all the subconstracts that more than 20% is accepted. The value of unexplained variance by 1^{st} contrast (size) to be in the desired specification is less than 15% for all subconstract.

Table 6: Unidimensionality: Standardized Residual Variance for each Knowledge Sub-Construct

Contruct	Subconstruct	Varian explained by measure (%)	Unexplained variance by 1^{st} contrast (size)
Skill	Designing Skill	51.3	5.7(21.2%)
	Sketching Skill	60.7	7.2(13.5%)
	Applying Technology Skill	59.2	3.2(11.8%)
	Designing in marketing Skill	46.9	2.3(17.5%)

Table 6 shows an item having a residual value correlation that exceeds 0.7 logits. Skill items are K6C3, K8C8, K6C10, K7C16, K7C9, K7C10, K7C13, K7C14, K9C4, K9C5, K9C5, K9C6, K7C6, K77C7, K9C4, K9C6, K7C2, K7C3, K6C8 AND K6C9. All these items go through the filter process by looking at the value of seeing MNSQ values approaching the value of 1.00 and ZSTD approaching the value of 0.00.

Table 7: Largest Standardized Residual Correlations Used to Identify Dependent Item

Construct	Correlation	Entry Number	Item	Entry Number	Item
Skill	1.00	3	K6C3	35	K8C8
	1.00	10	K6C10	26	K7C16
	1.00	19	K7C9	20	K7C10
	.91	23	K7C13	24	K7C14
	.91	39	K9C4	40	K9C5
	.88	40	K9C5	41	K9C6
	.87	16	K7C6	17	K7C7
	.86	39	K9C4	41	K9C6
	.85	12	K7C2	13	K7C3
	.80	8	K6C8	9	K6C9

3.5 Item Difficulty and Respondent's Ability

Figure 1 below represents item difficulty locations and distribution of examinees along the logit scale. Item difficulty measures from +1.19 to -1.19 logit. Meanwhile, the respondents' ability to estimates from +4.39 to -1.70, which was slightly higher than the item difficulty measurement. The mean for both measurements was approximately around the same location, thus indicating that the items for this sample were well targeted. The map had greatly

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assisted the researcher in locating the area where most items were located particularly to see whether this is parallel with the spread of the respondents.

All the items were scattered and point towards the ability of respondents' diversity. Respondents that having high satisfaction located at the above of the scale, while the respondents that having low satisfaction were located below of the scale. The arduous items were K6C10 and K7C16 (1.19 logit) which located on the near upper scale. While the easiest item ~~is~~ was K7C13 (-1.19 logit). This signified that the difficult items can only be answered by the highly capable respondents, while the easier item can be easily answered by either respondent of high ability or low ability (Linacre, 2007).

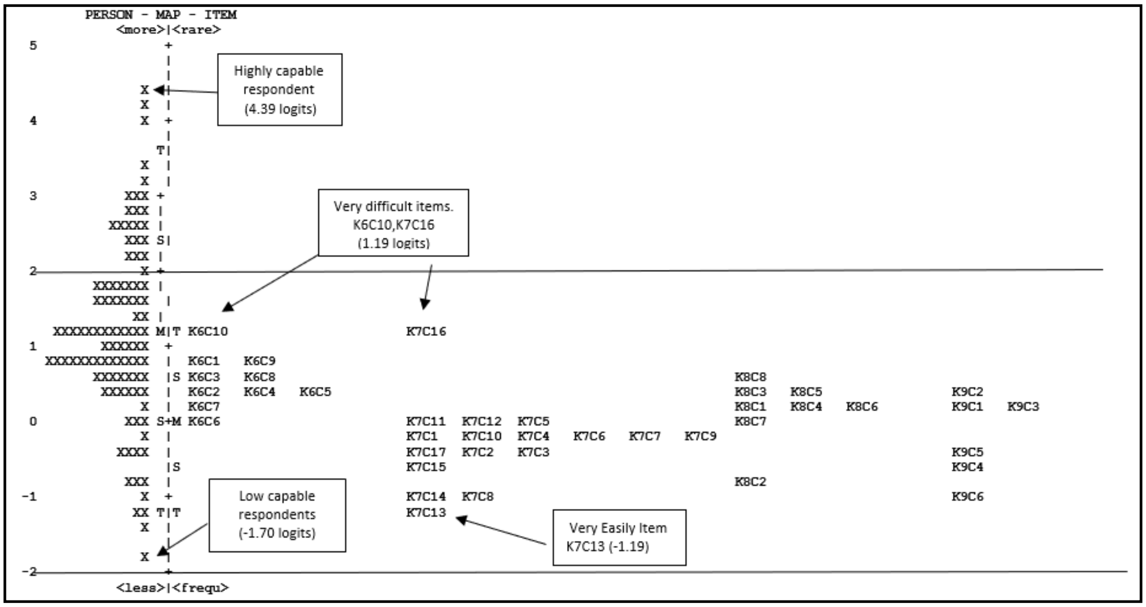

Figure 1: Items Map of Skill Items

After data analysis, each item is being revised following the standard index and the conditions that must be followed to achieve the standards of validity and reliability of the instrument based on the Rasch measurement model. The item removal refines, and purification were conducted by referring and considering the views and expert evaluation. Based on the results obtained, there are 12 skill items that do not meet the requirements analysis and should be discarded. Whereas items are appropriately refined in accordance with the context and significance of the study. 25 items were retaining from 41 items. Overall summary of the related items in the questionnaire is shown in Table 8 below.

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Table 8: The Summary of Items Drop, Refine and Retained

Construct	Item	Total item	Item Drop	Total Item Drop	Item Refine	Total Item Refine	Item Retain	Total Item Retain
Skill	K6C1 -P1C13	13	K6C1 K6C2 K6C6	3	K6C5 K6C3 K6C8 K6C7 K6C4 K6C13	6	K6C9 K6C10 K6C11 K6C12	4
	K7C1 -K7C21	21	K7C6 K7C8 K7C15 K7C14	4	K7C7 K7C11 K7C12 K7C9 K7C5	5	K7C1 K7C2 K7C3 K7C4 K7C10 K7C13 K7C16 K7C17 K7C18 K7C19 K7C20 K7C21	12
	K8C1 -K8C11	11	K8C5 K8C7 K8C3	3	K8C1 K8C2	2	K8C4 K8C6 K8C8 K8C9 K8C10 K8C11	6
	K9C1 -K9C7	7	K9C1 K9C6	2	K9C3 K9C7	2	K9C2 K9C4 K9C5	3

Based on this research, it can be concluded that the validity and reliability of an instrument is a very important aspect to be considered in developing a new instrument for a study. Overall from this analysis, it is found that a total of 25 items that have been dropped were questionable items on validity and reliability. Thus, based on the validity and reliability test made on this instrument, it exhibited that this instrument is fits to be used by schools or

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other researchers for future study. This analysis entailed implication where it helped researchers in developing a good instrument for the school subject.

IV. CONCLUSION

As a conclusion of the analysis, a mastering D&T measurement instrument has been developed. This instrument consisted of four elements. The researchers contend that this instrument can be used by the related parties in producing high-skilled work force. Consequently, this research findings could contribute and be used as a guidance by the Technical and Vocational Education Curriculum Development Department and other stakeholders in producing individuals who possess high acquaintance of design and technology subject. Benson (2009), concluded that whilst good practices in design and technology is developing, teacher knowledge remains a significant barrier for effective national practice. Meanwhile, (Arasinah et al., 2014), mentioned a good instrument can also assist employers to develop various trainings to increase the level of skills in order to improve their work performances and competencies.

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