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Validity and Reliability of Measurement Instruments Using the Rasch Model: Preschool Teacher Readiness for STEM Implementation in Malaysia

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Four disciplines namely Science, Technology, Engineering and Mathematics are being implemented in the teaching process at the preschool level. It grants children the opportunity to explore the learning process in a real, realistic and meaningful context. The purpose of this study is to identify the readiness of preschool teachers in Malaysia to execute STEM. The survey used a 5-point Likert scale questionnaire. It was circulated to 2300 preschool teachers nationally through Google Forms. The validity and reliability of the g-STEM questionnaire were measured with the Rasch Measurement Model, using Winstep software version 3.68.2. Rasch analysis revealed that the individual reliability index was 0.96 and the item reliability was 1.00. From the polarity of the item, it was established that each contributed to the measurement of teacher readiness for STEM, as the PTMEA CORR value of each item was between 0.41 and 0.77, which exceeded 0.40. Item comparability tests indicated that none of the items in the questionnaire were to be eliminated, because the mean square value of the items ranged from 0.69 to 3.89, and the mean square value of the items was dispersed from 0.68 to 3.91. The items in the questionnaire were positioned in an escalation continuum for the measurement of preschool teacher readiness for STEM implementation. Hence, the findings substantiated the g-STEM questionnaire constructs. The Rasch Measurement Model has ascertained that the g-STEM questionnaire has a high level of validity and reliability for utilization in measuring teacher readiness.

Key words: *STEM, Rasch Model, Preschool, Validity, Reliability.*

Introduction

STEM is an acronym for Science, Technology, Engineering and Mathematics. Nonetheless, the integration of these four disciplines is considered more appropriate and relevant for the teaching and learning process, because of its practical and realistic aspects (Mazlini et al., 2017; Sneideman, 2013). Through this integration, children are given the opportunity to learn Science and Mathematics in real, realistic and meaningful contexts, through technology and design applications. The process of teaching and learning through this approach is more fun, as it involves hands-on activities and provides a lively experience that stimulates children to think and solve problems.

Early childhood STEM exposure can have numerous functions; it can build on the basics of learning and development, and develop mindfulness, help to develop critical thinking and reasoning skills, increase interest in both Science and Mathematics learning, and STEM-related careers, develop curiosity, inquisitiveness and investigative characteristics, as well as providing children with extensive experiences of the natural and artificial worlds around them (Bybee, 2013; National Research Council (NRC), 2011; Hoachlander & Yanofsky, 2011; Katz, 2010).

Thus, teachers play an important role in implementing STEM in early childhood education. The knowledge and expertise in designing STEM integrations need to be addressed by every educator, to nurture children's interest in Science and Mathematics. Additionally, through STEM, teachers can provide opportunities for children to investigate and explore scientific and mathematical concepts. Furthermore, when integrated with the field of Technology and Engineering, it can create a more meaningful learning environment that could challenge and enhance critical and creative thinking skills in solving real life problems, and can provide children with very effective learning experiences (Mazlini et al., 2017; Sneideman, 2013).

For the purpose of this study therefore, the Rasch Model has been used as a measurement framework, being a measurement and mapping model (Masters, 1982).

Problem Statement

Experts in early childhood education suggest that STEM should be implemented from an early age (Mazlini et al., 2017; Katz, 2010). This is closely related to the findings of previous studies which show that teachers have succeeded in implementing STEM at the age of 3–4-years among PERMATA (preschool) children. In fact, through STEM Modules, a total of four to five STEM projects have been successfully implemented within five (5) months.

STEM integration is also said to be very easy to implement within the PERMATA Negara Curriculum, because of the availability of STEM-based learning areas such as Science and Mathematics (Mazlini et al., 2017).

However, there are also previous studies which show that STEM implementation at preschool is not satisfactory. Among the factors contributing to the weakness of STEM implementation at preschool are teachers not integrating STEM elements during the teaching process, and weaknesses in pedagogical content knowledge (Pearson & Pearson, 2017; Chang & Park, 2014). Hence, levels of pupils' satisfaction with the quality of science teaching is low. Only 15% of students are satisfied with the teaching, and 60% report that science teaching is tedious and unattractive (Serafin, 2016). In addition, memorisation teaching techniques, as well as teacher-centred teaching and learning methods are still practised, prevents pupils' active involvement (Ceylan & Ozdilek, 2015; Gambari & Yusuf, 2015).

Nevertheless, some researchers have perceived that STEM implementation would be more effective when integrated with educator readiness and quality (Johnson, Peters-Burton & Moore, 2015). Quality teachers will consistently deliver knowledge that is engaging and capable of implementing STEM, through appropriate teaching methods for children (Chang & Park, 2014).

As such, this study will examine educators' readiness in terms of pedagogical practices, the use of technology, the process of engineering design and the development of professionalism in implementing STEM at the preschool level in Malaysia.

Objective of the Study

Generally, this study intends to achieve the following objectives:
i. identify the separation and reliability indices of items and persons, using the Rasch Measurement Model;
ii. determine items' polarity using the Rasch Measurement Model, and
iii. identify a person-item distribution map, to evaluate teachers' readiness in STEM implementation.

Significance of the Study

The results of this study are expected to have a positive impact and ability to enhance knowledge, particularly in terms of STEM teacher practice pertaining to teaching and learning methods. This is in line with the national education blueprint i.e. the Malaysian Education Development Plan; one of the core aims of which is to improve the quality of teaching and learning. Therefore, lecturers may also recommend that teacher trainees or teachers use methods that foster twenty-first century skills. In addition, schools will be able to produce human capital that has the mind and skills to meet the demands of the job market. This is one feature of human capital that needs to training from an early age. It is necessary because reforms in early childhood education require great commitment, especially from teachers.

Studies on STEM implementation at preschool level are still lacking. Therefore, this study aims to provide opportunities for other researchers who are interested in exploring this area of research. The findings of the study are expected to contribute to other researchers exploring the development and quality of teachers in classrooms, particularly in the field of STEM implementation. Furthermore, they can also provide an alternative for teachers to improve their self-esteem through a STEM support program, a professional development course required by teachers to overcome STEM implementation constraints. Therefore, expanding research in the field of STEM implementation in Malaysia is important, especially in testing teachers' readiness to implement STEM at the preschool level.

Literature Reviews

STEM Education

STEM education in Malaysia has thus far integrated all the four STEM fields, to prepare students for future challenges. STEM education fails to achieve its purpose if its elements are implemented disparately.

Descriptions of real-world contexts, involving the concepts of science, mathematics and the application of technology and design, are the methods used in STEM education (Word, 2016). Students' interest in STEM fields is pertinent to the education system, because STEM-related careers are important to improve the future economy and quality of life (Word 2016; Mazlini et al., 2016; Kassaee & Rowell, 2016). Like many other countries, Malaysia is also working to increase knowledgeable labours in the field of STEM.

Student engagement in STEM subjects at school level, however, has not yet reached the national goals (Adnan et al., 2016; Fjortoft et al., 2018). Change after change has been made to revise the purpose, structure, function and process of various approaches. In this regard, the entire education system, especially educators, must be willing to accept any changes and able to implement them efficiently and effectively.

Attitudes towards STEM Education

Brown et al., (2016) stated that students' interest and positive attitude towards involvement with STEM increased after implementing STEM activities. In fact, the future of the world is more concerned with job-based skills in the field of STEM. Therefore, students should have the skills and qualifications in the relevant fields to meet the challenges of the job environment.

However, a study found that teachers still use traditional methods in STEM teaching and learning. The impact of STEM teaching and learning is becoming more tedious (Tseng et al., 2016). Teachers also emphasise understanding of theory more than practical work, which reduces opportunities for students to apply STEM knowledge in their daily lives (Brown et al., 2016).

The Implementation of STEM Education

According to Han et al., (2015a), teacher readiness is the key factor in realising a teaching method that gives meaning to students. Therefore, to succeed in implementing STEM at schools, teachers need to be aware of students' trust in a given learning process (Han et al., 2015a). According to Brown et al., (2016) in order to increase students' interest in the field of STEM, teachers should know and be aware of students' existing knowledge and beliefs in STEM education. Tseng et al. (2013) state that interest in STEM will increase as teachers are able to use various technologies during the teaching process.

According to Yildrim and Sahin-Topalcengiz (2018), teachers need to equip themselves with STEM knowledge; the pedagogy, integration in the twenty-first century curriculum, as well as context and skills. Most STEM-related studies highlight this knowledge as a necessary aspect of any teacher seeking STEM education. Teachers should be more forward-thinking than students, especially in dealing with generations exposed to technological developments without boundaries (Tseng et al., 2013). Collaborations among teachers from all fields of STEM can also create and develop an effective teaching method, and give meanings for students to integrate STEM Education. Teachers' efforts in acquiring STEM knowledge and skills need to be broadly integrated into STEM Education teaching strategies (Brown et al., 2016).

Research Methodology

Research Design

This is a descriptive study using a survey method which involved the collection of quantitative data. Questionnaires requested knowledge of the pedagogical approach practised, the level of inquiry-based practice, teaching aids, engineering design processes and the professional development needed to implement STEM in classrooms.

Participants and Location Selection

This study involved 2300 preschool teachers of KEMAS. Purposive sampling method was used to select respondents. Table 1 shows the demographic profile of the respondents who answered the survey questionnaire. Respondents' profiles included gender, age, ethnicity, academic qualification and workplace.

Table 1: Respondent Profile

Demography Factors	Category	Frequency	Percentage (%)
Gender	Male	22	1
	Female	2284	99
Age	20-25	51	2.2
	26-30	365	15.8
	31-35	638	27.7
	36-40	296	12.8
	Above 41	956	41.5
Ethnicity	Malays	1864	80.8
	Others	439	19
Academic Qualification	SPM	550	23.9
	STPM	53	2.3
	Diploma	1495	64.8
	Degree	201	8.7
	Masters	6	0.3
	Ph.D.	0	0
Workplace	Perlis	66	2.9
	WP Kuala Lumpur	52	2.3
	Negeri Sembilan	140	6.1
	Melaka	61	2.6
	Johor	703	30.5
	Pahang	362	15.7
	Terengganu	50	2.2
	Kelantan	76	3.3
	Sabah	176	7.6
	Sarawak	579	25.1
	WP Putrajaya	35	1.5

Data Collection Procedures

Questionnaire

The instrument for this study is a questionnaire. It requires feedback from teachers regarding the knowledge of the pedagogical approach practised, the level of inquiry-based practice, teaching aids, engineering design processes and the development of professionalism needed in implementing STEM in the classroom.

The questionnaire was administered using a Google Forms application. It was distributed using smartphone and tablet devices with study participants. The Google Forms application was selected as a platform to facilitate the management of data and interaction with study participants.

The questionnaire consists of six main sections: Part A – demographic information comprised of gender, age, ethnicity, academic qualification and workplace; Part B – Pedagogy; Part C – Science Inquiry; Part D – Learning resources or materials; Part E – Engineering Design Processes, and Part F – Professionalism Development Course. This questionnaire uses a 5-point Likert scale to measure the overall items evaluated. The survey includes 45 items adapted and modified from Surif et al. (2014) and Ong et al. (2016). It has the following number of items per constructs: Part B contains 17 items, Part C has eight items, Part D possesses 10 items, Part E has five items, while Part F offers five items.

Data Analysis

The Item Response Theory Model (IRT Model) was first tested, to determine the suitability or accuracy of the model against the data. The IRT Model is based on the number of parameters (1,2 and 3), to describe the item response function (IRF) (Siti Rahayah, 2008). The best model depends on the type of test items and their scores. If the response-free items change in terms of difficulty, rather than in comparison, the one-parameter model is deemed the most appropriate. Thus, the IRT model used in most psychological tests is the Rasch Model or known as 1-Parameter Logistic Model (1PL).

Rasch Model refers to an idea, principle, guideline or technique that enables a measurement to be performed on a latent trait. This is because the measurement in question does not only refer to the percentage or highest number of a score, but it allows the creation of a measurement scale similar to the scientific measurement scale which allows for weight or height measurement. This model has been widely used in many fields, especially in education assessment and education psychology to measure levels of achievement and cognitive assessment (Azrilah, 2011).

In the Rasch analysis, two key assumptions need to be examined. The first assumption pertains to the idea that the size of each item's difficulty should be consistent with the expectation of the model. In fact, this assumption can be checked by examining two compatibility statistics, namely squared mean accuracy (MNSQ). The value range between 0.6–1.4 logit on Likert scale indicates that this assumption is met (Bond & Fox, 2007; Wright et al., 1994). This indicates that the response of the sample studied is as predicted by the Rasch Model. Responses outside of this range indicate that measurements made will calibrate aspects other than the actual construction being measured. The second assumption is that the constructs measured using Rasch analysis should be unidimensional. This uni-dimensionality means that only one main construct is measured and not another (Siti Rahaya, 2008).

This study used three statistics to achieve its objectives. Firstly, the item difficulty measure was used to provide the operational definition of the measured construct. The key and important issues are defined as items that show high item difficulty size statistics. This means that many respondents chose a Likert 2 scale, which indicates the item is problematic. If so, a non-trivial problem is defined as an item of low difficulty size.

Sample reliability index refers to the degree to which the response obtained is consistent when using different samples, while the item separation index refers to the extent to which SSMM is able to distinguish between levels of item difficulty. Thus, for both the individual reliability index and the item separation index, high values indicate good measurement quality. The results of this study were descriptively analysed using the Statistical Package for Social Sciences program version 25, before being analysed with the Winsteps Version 3.68.2 program to be analysed under the Rasch Model for polytomous data (Hussain et al., 2019).

Findings and the Discussion of the Study

Reliability Indexes of Items and Person

The analysis shows that the individual reliability (Figure 1) is 0.96 and the item reliability is 1.00. The individual reliability value exceeds 0.8 while the item reliability exceeds 0.9, proving the adequacy of the study's respondents. For individual reliability, the items used were able to distinguish between individuals for the variables measured in this study. Both values indicate that this instrument can measure teacher practice in STEM teaching and learning. The analysis also shows that the constructs found in this instrument are good because they have high reliability, and are in excellent condition and effective with a very high degree of consistency (Bond & Fox, 2007).

Separation Indexes of Items and Person

The separation indices for individuals reflects the number of strata for pedagogical practice identified in the respondent group, while the item separation index indicates item difficulty level (Mohd Kashfi, 2011). A good value for individual and item separation must exceed 2. In fact, the value of individual separation index increases if the test is administered to a larger sample (Linacre, 2005). Figure 1 shows the individual separation value of 2300 respondents divided into five strata (4.66) individual practices (teachers) measured in this study. However, the actual item separation value is 21.17.

Figure 1. Separation indexes of item and person

Summary of 2300 Measured Persons

	RAW SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	170.5	45.0	1.66	.26	1.09	-.1	1.01	-.4
S.D.	22.3	.0	1.49	.04	.73	2.7	.63	2.6
MAX.	224.0	45.0	7.54	1.01	6.54	9.9	5.74	9.9
MIN.	92.0	45.0	-2.83	.23	.17	-6.1	.16	-6.2

REAL RMSE .31	ADJ.SD 1.46	**SEPARATION**	**4.66**	**PERSON RELIABILITY**	**.96**
MODEL RMSE .26	ADJ.SD 1.47	SEPARATION	5.57	PERSON RELIABILITY	.97
S.E. OF PERSON MEAN = .03					

Person Raw Score-To-Measure Correlation = .99
Cronbach Alpha (Kr-20) Person Raw Score Reliability = .97

Summary of 45 Measured Items

	RAW SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	8714.9	2300.0	.00	.04	1.00	-2.3	1.01	-2.3
S.D.	832.2	.0	.81	.00	.48	6.5	.49	6.6
MAX.	9837.0	2300.0	2.53	.04	3.89	9.9	3.91	9.9
MIN.	5718.0	2300.0	-1.45	.03	.69	-9.9	.68	-9.9

REAL RMSE .04	ADJ.SD .81	**SEPARATION**	**21.17**	ITEM	**RELIABILITY 1.00**
MODEL RMSE .04	ADJ.SD .81	SEPARATION	22.24	ITEM	RELIABILITY 1.00
S.E. OF ITEM MEAN = .12					

Umean=.000 Uscale=1.000
Item Raw Score-To-Measure Correlation = -.93
103500 Data Points. Log-Likelihood Chi-Square: 175891.32 with 101034 D.F. P=.0000

This value indicates that the item is well-dispersed and capable of delivering high reliability. Thus, the larger the value of the separation index, the better the instrument quality of respondents and groups of items used in this study (Sumintono & Widhiarso, 2014), in line with Linacre's (2005) suggestion that > 2 separation index is good.

Item Polarity in Determining the Validity of the Measured Construct

Point Measure Correlation Coefficient (PTMEA CORR) is used to detect item polarization for the purpose of testing the extent to which construct development attains its goals, and it is an early detection of construct validity (Bond & Fox, 2007). If the value of PTMEA CORR exceeds 0.30 and has a positive value (+) (Linacre, 2010; Bond & Fox, 2007), then it indicates that the item can measure the construct that it purports to measure.

The high polarity of the item indicates that the item is capable of differentiating between respondents. On the other hand, if the value is negative (-), the item being developed does not measure the construct that should be measured. The item needs to be repaired or dropped because it is difficult to answer.

The results show (Table 2) that 44 items had positive values. This result indicates that these items are moving in a direction with the construct, are able to measure the construct and are not in conflict with the construct to be measured. This finding shows that 44 (97.8%) items succeeded in measuring the construct to be measured, whereas only 1 (2.2%) item comprised the PTMEA CORR index at a negative value. This indicates that this item cannot measure the construct to be measured. However, this item is clean and thus maintained.

Table 2: Item Polarity

Input: 2300 Persons 46 Items Measured: 2300 Persons 45 Items 212 Cats 3.68.2

Person: Real Sep.: 4.66 Rel.: .96 ... Item: Real Sep.: 21.17 Rel.: 1.00

Item Statistics: Correlation Order

ENTRY NUMBER	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	ITEM	G
1	5718	2300	2.53	.03	3.89	9.9	3.91	9.9	-.29	.70	30.2	57.9	B1	0
26	9159	2300	-.57	.04	1.43	9.9	1.61	9.9	.43	.63	60.6	62.4	D1	0
2	8886	2300	-.14	.04	1.38	9.9	1.58	9.9	.47	.64	61.5	62.5	B2	0
41	9275	2300	-.34	.03	1.22	6.9	1.31	7.4	.57	.65	55.8	56.6	F1	0
43	9264	2300	-.42	.03	1.19	6.0	1.27	6.4	.59	.65	54.7	56.5	F3	0
42	9407	2300	-.47	.03	1.15	4.7	1.21	5.2	.59	.64	59.3	57.6	F2	0
30	7152	2300	1.54	.03	1.34	9.9	1.36	9.9	.60	.71	47.3	53.7	D5	0
45	9451	2300	-.63	.03	1.07	2.4	1.08	2.0	.61	.64	60.1	57.8	F5	0
44	9420	2300	-.62	.03	1.07	2.3	1.09	2.2	.62	.64	60.0	57.9	F4	0
4	9837	2300	-1.45	.04	.95	-1.8	.89	-2.9	.62	.59	66.2	63.3	B4	0
33	7065	2300	1.69	.03	1.22	6.9	1.24	7.6	.62	.69	49.2	55.1	D8	0
6	8067	2300	.49	.04	1.06	1.8	1.06	2.0	.63	.65	63.7	60.8	B6	0
31	7170	2300	1.56	.03	1.18	5.7	1.20	6.2	.63	.69	50.7	55.6	D6	0
29	8019	2300	.67	.03	1.13	4.2	1.13	4.0	.64	.69	59.3	55.8	D4	0
32	7479	2300	1.29	.03	1.14	4.5	1.16	5.1	.64	.69	53.4	55.3	D7	0
20	8561	2300	-.05	.04	.98	-.5	.99	-.2	.64	.64	66.8	62.8	C3	0
28	9440	2300	-.08	.04	.92	-2.8	.90	-3.2	.65	.62	65.4	62.1	D3	0
8	9428	2300	-1.00	.04	.90	-3.5	.88	-3.7	.66	.61	69.6	64.3	B8	0
27	9799	2300	-1.05	.04	.86	-5.3	.81	-5.5	.66	.59	71.0	65.0	D2	0
24	8123	2300	.39	.03	1.00	.0	1.00	-.1	.66	.66	62.8	59.3	C7	0
16	9123	2300	.08	.04	.89	-4.0	.88	-4.1	.67	.62	68.3	64.0	B16	0
34	7643	2300	1.10	.03	1.07	2.3	1.07	2.4	.68	.70	56.0	54.2	D9	0
35	8340	2300	.45	.03	.99	-.3	1.00	.0	.68	.67	62.7	56.9	D10	0
3	9170	2300	.08	.04	.86	-4.9	.86	-4.8	.68	.62	69.2	64.4	B3	0
13	9027	2300	-.53	.04	.87	-4.6	.88	-4.0	.68	.62	72.6	65.1	B13	0
11	9296	2300	-.21	.04	.83	-5.9	.82	-6.0	.69	.60	71.0	66.5	B11	0
9	8396	2300	-.07	.04	.88	-4.3	.88	-4.2	.69	.64	67.7	62.6	B9	0
15	9389	2300	-.58	.04	.82	-6.9	.80	-7.0	.69	.60	70.7	65.7	B15	0
5	8778	2300	-.27	.04	.85	-5.4	.85	-5.2	.70	.63	68.5	62.6	B5	0
18	9478	2300	-.49	.04	.79	-7.8	.77	-7.8	.70	.61	71.6	64.5	C1	0
7	9184	2300	-.84	.04	.81	-6.9	.80	-7.0	.71	.62	70.9	64.4	B7	0
17	8890	2300	-.78	.04	.82	-6.6	.80	-6.9	.71	.62	71.8	64.4	B17	0
12	9317	2300	-.27	.04	.79	-7.8	.77	-7.9	.71	.61	70.8	64.8	B12	0
14	9223	2300	-1.03	.04	.79	-7.6	.76	-8.1	.71	.60	73.6	66.6	B14	0
10	9426	2300	-.56	.04	.77	-8.8	.75	-8.6	.71	.60	73.6	66.3	B10	0
19	9070	2300	.14	.04	.78	-8.2	.76	-8.5	.73	.62	70.7	64.1	C2	0
21	9071	2300	-.02	.04	.74	-9.9	.72	-9.9	.74	.61	73.4	65.6	C4	0
36	8880	2300	-.59	.04	.72	-9.9	.70	-9.9	.76	.62	73.1	64.4	E1	0
38	8324	2300	.26	.04	.76	-8.8	.75	-9.0	.76	.65	69.2	60.9	E3	0
39	8044	2300	.53	.04	.76	-8.5	.76	-8.6	.76	.65	70.4	60.4	E4	0
40	8057	2300	.51	.03	.76	-8.6	.76	-8.7	.76	.66	69.6	59.8	E5	0
25	8745	2300	-.41	.04	.71	-9.9	.70	-9.9	.76	.63	70.4	63.3	C8	0
22	8873	2300	.37	.04	.69	-9.9	.69	-9.9	.77	.62	72.8	64.0	C5	0
23	8876	2300	.37	.04	.69	-9.9	.68	-9.9	.77	.62	73.0	64.4	C6	0
37	8831	2300	-.57	.04	.69	-9.9	.68	-9.9	.77	.63	70.9	63.2	E2	0
MEAN	8714.9	2300.0	.00	.04	1.00	-2.3	1.01	-2.3			64.9	61.5		
S.D.	832.2	.0	.81	.00	.48	6.5	.49	6.6			8.8	3.8		

Item Difficulty Level Based on the Construct

A person-item distribution map visualises the complexity of items in the instrument, against teachers' readiness for pedagogy practised during STEM implementation, across the scale of logits on one continuum of measurement, from the simplest to the most difficult (Bond & Fox, 2007).

Table 2 shows 45 items of pedagogical practice used by teachers during the STEM teaching and learning process conducted on the 2300 study respondents. The data shows the top right is a construct measuring pedagogical practices that are difficult to accept. The bottom right shows a construct measuring pedagogical practices that are easily agreed upon.

The person-item distribution mapping (Figure 2) shows whether the items administered correspond to the respondent's ability. The sign (#) represents 17 individuals, while the sign (.) represents a respondent and the item is placed adjacently and separated by a dotted line. The dotted line represents the location of the respondents' pedagogical practices and the level of difficulty of the items on a logit scale. To the left of the dotted line is the position of the respondents with a high pedagogical practice size. The top right of the map is the position of the item with the highest difficulty. The two letters 'M' in the dotted line represent the measure of the mean (average) ability of the individual (left), and the item (right). The letter 'S' on the right represents a standard deviation for the item. The letter 'T' shows two standard deviations for the individual (teacher) and two standard deviations for the item (left).

Therefore, Item B1, "I provide information or facts in a passive interaction with children" was the most difficult to agree upon item with a value of +3.02 (N = 2300, score 5718, average 2.48 (5718/2300). Item B4, which is "I involved all children in a project activity" is the most agreeable logit size = -1.31 (N = 2300, score 9837, average 4.27 (9837/2300).

Figure 2. Person-Item distribution Mapping

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INPUT: 2300 PERSONS  46 ITEMS MEASURED: 2300 PERSONS  45 ITEMS  212 CATS 3.68.2
      PERSONS - MAP - ITEMS
               <more>|<rare>
   8                 +
                     |
                  .  |
                     |
   7                 +
                  .  |
                  .  |
                     |
   6             .#  +
                  .  |
                  .  |
                  .  |
   5              .  +
                 .# T|
                 .#  |
                .##  |
   4             .#  +
                ###  |
                .##  |
             .##### S|
   3            .##  +
           .######   |
          .#######   |  B1
           .######   |
   2 .############   +
        .######### M|  D8
       .##########   |T D5     D6
        .#########   |  D7
   1     .########   +  D9
         .########   |S D4
           .######   |  B6     C7     D10    E4     E5
             .##### S|  C2     C5     C6     E3
   0         .#####  +M B16    B3     B9     C3     C4     D3
              .####  |  B11    B12    B2     B5     F1
             .#####  |  B10    B13    B15    C1     C8     D1     E1     E2
                        F2     F3     F4
                .##  |S B17    B7     F5
  -1             .#  +  B14    B8     D2
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Conclusion

In summary, the main objective of this study was to examine teachers' readiness to implement STEM at the preschool level. The study occurred in terms of pedagogy, inquiry practice, use of teaching aids, the process of designing engineering elements during the teaching and learning process, and the need for professional development courses in implementing STEM. This section answers and discusses all research questions and includes measurement quality.

Quality of Measurement

In 1979, Wright and Stone gave the conditions for producing a useful measurement. They specified the use of a valid item in the measurement process, and the determination of the construct size, a crystal-clear concept and definition of the construct and in accordance with the theory, testing the item against the appropriate individual to produce reliable results with the purpose of measuring and using a valid response pattern. Thus, the criteria used in the present study were the benchmarks for determining the validity of the g-STEM questionnaire, including the validity of the 45 items used to have a polarity of items with a MTMEA CORR greater than 0.3.

Additionally, all items recorded infit mean squared ranged from 0.69 to 3.89, and outfit mean squared ranged from 0.68 to 3.91. Meanwhile, the individual reliability value was 0.96 and the item reliability was 1.00. The individual reliability value exceeded 0.8 while item reliability exceeded 0.9, to prove that the survey respondents are adequate. For individual reliability, the items used were able to distinguish between individuals for the variables measured in this study. This indicates that there is a high potential for replication of results when using different samples. Meanwhile, the index value of the item separation exceeded 2 (acceptable) (Jones & Foxes, 1998). In conclusion, reliability indexes of person and item separation index indicate that good measurement was performed in this study. Both values indicate that this instrument can measure teacher readiness in STEM teaching and learning processes.

Next; the MNSQ value and the polarity of the item. The MNSQ is a mean squared fit statistic with an expected value of 1.00 (Linacre, 2005). This study refers to the quality of measurement with an MNSQ acceptance range of 0.6 to 1.4 (Bond & Fox, 2007). Findings show that the MNSQ values for infit and outfit are within the specified range.

Item comparability tests showed that no items in the questionnaire were to be dropped. The mean squared value of the items ranged from 0.69 to 3.89, and the mean squared value of the items ranged from 0.68 to 3.91. The items in the questionnaire were arranged in a continuous contour for the measurement of preschool teacher readiness for STEM implementation. This finding confirms the g-STEM questionnaire construct. The Rasch Model has proven that g-STEM questionnaires have a high level of validity and reliability when measuring teacher readiness.

Implications of the Study

Interest in science, technology, engineering and mathematics (STEM) needs to be nurtured early in childhood, to produce more outstanding professionals in the field. Therefore, this study can provide the idea and the impression that, (i) preschool teachers need to be trained to be STEM specialists, (ii) efforts to implement STEM education at the preschool level to ensure continuity, (iii) student teachers participating in early education programs are required to take science and mathematics courses, and (iii) a STEM Education Policy must be established in order for the Government to provide a budget for STEM implementation at the preschool level. In fact, the policy also requires the private sector, Government-Linked Companies (GLC), and industries to channel their funds and expertise through social responsibility services to develop STEM in the country.

REFERENCES

Azizah Zain. (2015).*Pelaksanaan Modul Projek Penyiasatan Dalam Meningkatkan Komunikasi dan Kemahiran Sosial Kanak-kanak Prasekolah.* (Tesis PhD tidak diterbitkan). Universiti Pendidikan Sultan Idris.

Azrilah, A.A. (2011). *Rasch Model Fundamentals: Scale Construct and Measurement Structure*. Kuala Lumpur: Integrated Advance Planning Sdn. Bhd.

Bagiati, A., & Evangelou, D. (2016). Practicing engineering while building with blocks: Identifying engineering thinking. European Early Childhood Education Research Journal, 24(1), 67-85.

Bond T. G. and Fox C. M, (2007) Applying the rasch model: fundamental measurement in the

Brown, J., Brown, R., & Merrill, C. (2016). Science and technology educators' enacted curriculum: Areas of possible collaboration for an integrative STEM approach in public schools. *Technology and Engineering Teacher*, *71*(4), 30.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. NSTA press.

Caci, B., Chiazzese, G., & D'Amico, A. (2013). Robotic and virtual world programming labs to stimulate reasoning and visual-spatial abilities. *Procedia-Social and Behavioral Sciences*, *93*, 1493-1497. doi:10.1016/j.sbspro.2013.10.070

Ceylan, S., & Ozdilek, Z. (2015). Improving a sample lesson plan for secondary science courses within the STEM education. *Procedia-Social and Behavioral Sciences*, *177*, 223-228.

Chang, Y., & Park, S. W. (2014). Exploring Students' Perspectives of College STEM: An Analysis of Course Rating Websites. *International Journal of Teaching and Learning in Higher Education*, *26*(1), 90-101.

Chong, O. S., Zamri Mahamod, & Hamidah Yamat. (2016). Faktor jantina, kaum, aliran kelas dan hubungannya dengan kecerdasan emosi murid dalam mempelajari Bahasa Melayu. *Jurnal Pendidikan Bahasa Melayu*, *3*(1), 12-23.

Dugger JR, W. E. (2014). " learning by doing" research INTRODUCTION. *Technology and Engineering Teacher*, *74*(1), 24.

Firman, H. (2016, February). Making graduate research in science education more scientific. In *AIP Conference Proceedings* (Vol. 1708, No. 1, p. 020001). AIP Publishing.

Fjortoft, N., Gettig, J., & Verdone, M. (2018). Teaching Innovation and Creativity, or Teaching to the Test?. *American journal of pharmaceutical education*, *82*(10).

Gambarı, A. I., & Yusuf, M. O. (2015). Effectiveness of Computer-Assisted Stad Cooperative Learning Strategy on Physics Problem Solving, Achievement and Retention.

Han, S. Y. (2013). *The impact of STEM PBL teacher professional development on student Mathematics achievement in high schools* (Doctoral dissertation).

Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education*, *13*(5), 1089-1113.

Han, S., Yalvac, B., Capraro, M. M., & Capraro, R. M. (2015a). In-service Teachers' Implementation and Understanding of STEM Project Based Learning. *Eurasia Journal of Mathematics, Science & Technology Education*, *11*(1).

Helm, J. H., & Katz, L. G. (2011). *Young investigators: The project approach in the early years*. New York, NY: Teachers College Press.

Hoachlander, G., & Yanofsky, D. (2011). Making STEM real. *Educational Leadership*, *68*(6), 60-65. Human Sciences, 2 nd ed. Mahwah, New Jersey: Lawrence Erlbaum.

Hussain, H.I., Grabara, J., Razimi, M.S.A., & Sharif, S.P. (2019) Sustainability of Leverage Levels in Response to Shocks in Equity Prices: Islamic Finance as a Socially Responsible Investment, *Sustainability*, 11 (12), 3260. https://doi.org/10.3390/su11123260

Husin, W. N. F. W., Arsad, N. M., Othman, O., Halim, L., Rasul, M. S., Osman, K., & Iksan, Z. (2016, June). Fostering students' 21st century skills through Project Oriented Problem Based Learning (POPBL) in integrated STEM education program. In *Asia-Pacific Forum on Science Learning and Teaching* (Vol. 17, No. 1, pp. 1-18).

Johnson, C. C., Peters-Burton, E. E., & Moore, T. J. (Eds.). (2015). *STEM road map: A framework for integrated STEM education*. Routledge.

Karpudewan, M., & Roth, W. M. (2018). Changes in primary students' informal reasoning during an environment-related curriculum on socio-scientific issues. *International Journal of Science and Mathematics Education*, *16*(3), 401-419.

Kassaee, A. M., & Rowell, G. H. (2016). Motivationally-informed interventions for at-risk STEM students. *Journal of STEM Education: Innovations and Research*, *17*(3), 77.

Katz, L. G. (2010). STEM in the early years. *Early childhood research and practice*, *12*(2), 11-19.

Katz, L., & Chard, S. C., & Kogan, Y. (2014). *Engaging children's minds: The project approach* (3rd ed.). ABC-CLIO, LLC: Santa Barbara, California.

Kementerian Pendidikan Malaysia (2013) Pelan Pembangunan Pendidikan Malaysia 2013-2015. KPM, Kuala Lumpur.

Linacre, J. M. (2005). A user's guide to Winsteps/Ministeps Raschmodel programs. Chicago, IL: MESA Press.

Masters, G. N. (1982). A Rasch model for partial credit scoring. *Psychometrika*, *47*(2), 149-174.

Mathers, N., Goktogen, A., Rankin, J., & Anderson, M. (2012). Robotic mission to mars: Hands-on, minds-on, web-based learning. *Acta astronautica*, *80*, 124-131. doi:10.1016/j.actaastro.2012.06.003

Mazlini, A, Tek, O. E., Aminah, A., Nasir, I. M.,., Jameyah, S., & Noriah, I. (2016). The Effectiveness of an In-Service Training of Early Childhood Teachers on STEM Integration through Project-Based Inquiry Learning (PIL). *Journal of Turkish Science Education*, *13*, 44-58.7.

Mazlini, A., Aminah, A., Tek, O.E, Mohd Nasir, I., Noriah. I., Jameyah, S. (2016). Enhancing Malaysian human capital from early childhood: A study in the feasibility and integrability of the STEM system in the PERMATA Negara curriculum. *Geografia Online Malaysian Journal of Society and Space, 12*(1), pp.29-36. MESA Press.

Mohd Kashfi Mohd Jailani. (2011). Manual pengenalan pengukuran Rasch & Winsteps. Bangi,

Nasir, M., & Yunus, H. M. (2017). Peranan Guru Tingkatan Enam Dalam Membentuk Pelajar Terarah Kendiri Dan Meningkatkan Kemahiran Abad Ke-21. *JuKu: Jurnal Kurikulum & Pengajaran Asia Pasifik*, *5*(1), 1-6.

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics*. National Academies Press.

Nolan, A., & Molla, T. (2017). Teacher confidence and professional capital. Teaching and Teacher Education, 62, 10–18. https://doi.org/10.1016/j.tate.2016.11.004.

Norazizah Abdul Rahman, Noor Ashikin Mohd Yusop, & Sopia Md Yassin. (2019). Kemahiran Proses Sains Dalam kalangan Kanak-Kanak Prasekolah Menerusi Pendekatan Projek. *Sains Humanika*, *11*(1).

Ong, E. T., Aminah Ayob, Md Nasir Ibrahim, Mazlini Adnan, Jameyah Shariff, and Noriah Ishak (2016). The Effectiveness of an In-Service Training of Early Childhood Teachers on STEM Integration through Project-Based Inquiry Learning (PIL). *Journal of Turkish Science Education (TUSED)*, *13*.

Pearson, G. (2017). National academies piece on integrated STEM. *The Journal of Educational Research*, *110*(3), 224-226.

Piaget, J. (2017). *The child's conception of physical causality*. Routledge.

Portsmore, M., Watkins, J., & McCormick, M. (2012). Planning, drawing and elementary students in an integrated engineering design and literacy activity. Paper presented at the 2 nd P-12 Engineering and Design Education Research Summit. Washington, DC.

Ramli, A. A. and Ibrahim, N. H. and Surif, J. and Bunyamin, M. A. H. and Jamaluddin, R. and Abdullah, N. (2017) *Teachers' readiness in teaching stem education.* Man in India, 97 (13). pp. 343-350 . Selangor: Universiti Kebangsaan Malaysia.

Serafin, C. (2016). No an Inquiry oriented 201- 207.

Siti Rahayah A. (2008). *Inovasi dalam Pengukuran dan Penilaian Pendidikan*. Bangi: UNiversiti Kebangsaan Malaysia.

Sneideman, J. M. (2013). Engaging children in STEM education early. *Washington DC: Natural Start Alliance, North American Association for Environmental Education*.

Sumintono, B., & Widhiarso, W. (2014). *Aplikasi model Rasch untuk penelitian ilmu-ilmu sosial (edisi revisi)*. Trim Komunikata Publishing House.

Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. 2013. Attitudes towards science, technology, engineering and mathematics (STEM) in a project based learning (PjBL) environment. International Journal Technology and Design Education, 23: 87–102.

Wright, B.D & Masters, G.N. (1982). *Rating scale analysis rasch measurement.* Chicago

Yildirim, B., & Sahin-Topalcengiz, E. (2018). STEM Pedagogical Content Knowledge Scale (STEMPCK): A Validity and Reliability Study. *Online Submission*.