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DEVELOPMENT OF INSTRUMENT IN POST OCCUPANCY EVALUATION FOR IBS HIGH-RISE RESIDENTIAL THROUGH RASCH MEASUREMENT MODEL

MOHAMMAD ASHRAF ABDUL RAHMAN[1], MOHD KAMARUZAMAN MUSA[1], NURZALINA HASHIM[1], MOHAMED NOR AZHARI AZMAN[2,*]

[1]Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600, Muar, Johor, Malaysia
[2] Faculty of Technical and Vocational, Universiti Pendidikan Sultan Idris, 35900, Tanjung Malim, Perak Malaysia
*Corresponding Author: mnazhari@ftv.upsi.edu.my

Abstract

High-rise building construction has exploded as a result of rapid worldwide urbanisation, and this trend appears unlikely to reverse in the near future. This study aimed to determine empirical evidence of the validity and reliability of the Post Occupancy Evaluation (POE) for high-rise residential building that developed using Industrialised Building System (IBS) method. The instrument of this study consists of 75 items that have distributed to 150 respondents that are residents of three IBS high-rise residential in Johor Bharu. This instrument was developed to assess ten POE constructs: spatial, design and aesthetics, physical, building materials, worker quality, comfort and well-being, environment and health, and maintenance, value, and cost. The Rasch Measurement Model is used to determine the validity and reliability of these POE instruments. The analysis conducted to study the reliability aspect and respondent- item isolation, polarity and suitability of the item measuring the construct and the standardised residual correlation values. The analytical results indicate that two items need to be eliminated, and the remaining 73 items are listed as appropriate items to be used to measure the ten POE instruments constructs. The findings of this study show that the developed instrument is highly valid and reliable and can be used in the Post Occupancy Evaluation of residential high-rise systems developed using the IBS method.

Keywords: Industrialized building system, Post occupancy evaluation, Rasch measurement model, Reliability, Validity.

1. Introduction

In Malaysia, the term of ‘industrial building system’ (IBS) refers to a construction approach in which components are created in a controlled environment, either on-site or off-site, and then placed and combined into construction works. The Ministry of Housing and Local Government (KPKT) introduced this method in 1964, IBS has undergone a remarkable evolution of industrial change [1]. According to statistics released by the Ministry of Works, housing projects contributed 30 per cent or RM38.1 billion of all construction projects in Malaysia and IBS have the potential to expand [2]. However, issues related to post-occupancy have caused the IBS method to be out of concern to Malaysians, especially home buyers [3]

Generally, post-occupational evaluation (POE) is defined is a method of gathering information regarding a building's performance in use, such as energy efficiency, indoor air quality (IAQ), occupant satisfaction, productivity. POE is a generalised concept that refers to overview of the programmes or procedures and strategies for evaluating existing buildings and facilities [4]. Hay et al. [5] reported that POE entails a comprehensive assessment of a resident's perception of the building. To values the credibility of the building to meet the resident’s requirements and identifies ways to improve it from various aspects, especially the design, performance and quality of the building [6, 7]. According to Hamzah [6]. POE also intended for assessing occupant’s dissatisfaction about the residential.

There are number of factors that influence buyer decision in buying house such as quality, price, location, promotion and corporate image [7]. From these factors, studies have indicated elements that need to be considered during the post-occupancy evaluation too. According to Rahman et al. [8], the quality of housing is one of the most dominant elements in this country, which has caused many residents to feel pressured by their homes after occupied. Some of the pressure that may encounter them is smaller space or spatial, unfit design and layout, the physical condition of the building, low quality of materials, and poor quality of work. Besides, aspects of performance also contribute to the dissatisfaction of many residents [9]. According to Mahrinasari and Pandjaitan [10] residents are constantly confronted with issues of discomfort because of highly distressed environments such as noise, safety threats, and resident's health. Furthermore, the deterioration of building performance may be caused by the difficulty of occupants to perform maintenance on damage or inefficiency in their homes [11]. Economic aspects also create for residents' dissatisfaction when they see their house is not value for money they spend when compared with the cost to bear, and performance expected is not worth the quality. The costs that residents must bear, including start-up costs, adaptation costs, and cost of repairs. Therefore, these three aspects, which are:

i. The quality aspect,

ii. The performance aspect, and

iii. The economic issue should be considered as a factor that can affect the residents' dissatisfaction for future improvement.

In the literature, there are various of the POE instruments have been developed in order to identify the dissatisfaction elements from the resident’s point of view [12]. For example, POE instruments for hospitals, offices, health clinics and universities. There are also POE instruments related to housing such as public housing, low-cost housing, or student housing. However, there is less study that emphasize on the POE instruments for IBS-type house. Therefore, this study intends to discover the importance of the POE instrument specifically for the IBS high-rise residential area. The primary aimed of the POE instrument development is to identify the dissatisfaction and IBS shortcomings.

Beforehand, this study has identified the important elements for the IBS housing post evaluation as presented in Fig. 1.

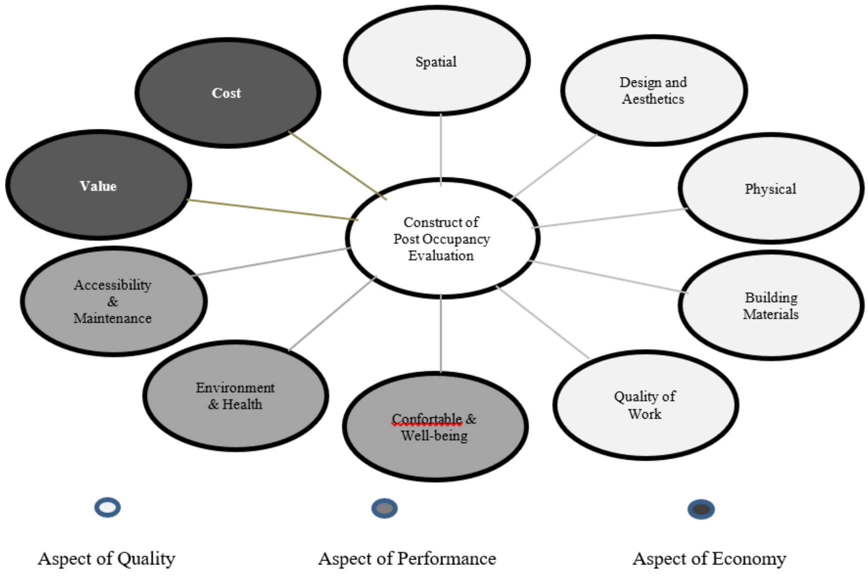

Fig. 1. The construction of POE instruments in terms of quality, performance and economy.

2. Literature Review

Post occupancy evaluation has been widely discussed in term of its history, protocol, process, benefits and limitation throughout various building construction. For example, residential, office, university, educational, medical, commercial, transport and government. Generally, POE project is conducted based three main levels, such as indicative, investigative and diagnostics.

In the literature, the POE serve wide range of purpose classification. First is direct POE purpose which is consist of determine occupancy perspective such as design, performance of energy, and facilities and maintenance [13-15]. In term of design evaluation which focus on examine the design, design features based on the occupancy's profile, or design process for certain projects.

Some studies have discussion the POE from the occupant's perspectives such as occupant's satisfaction and dissatisfaction, well- being, health, and comforts [16]. Additionally, some studies discovered factors that evaluate satisfaction levels, determine occupancy's opinion, user experiences, and asses the life productivity.

Recently, Lee et al. [4] and Roberts et al. [17] have collected, analyse and discussed the POE studies throughout various publication, from early years to present. From the reviews, there is a need on the evaluation of the occupant satisfaction in the post-occupancy stages as compared to the development of the buildings. Secondly, there are studies have discussed on the indirect POE purpose such as identify issues, determine future project, improve POE method, development POE instruments, improve standard and POE protocol, technologies used in POE and evaluate POE Model.

Besides, some studies have also found the importance of reverse engineering POE implementation to assist future design rather than merely reporting on an existing building's performance after completion. The POE implementation can be viewed from multiple point of view such as psychological and social impact [18].

3. Methodology

A questionnaire survey was designed in the study by using quantitative approach. This survey was distributed face- to- face. Primarily, this questionnaire design is verified by experts (*n* =3). The content, delivery, and design were checked and approved by experts who is familiar, and experience is instrument development.

This questionnaire was distributed randomly to three IBS residential complexes in Johor Bharu city centre by using face to face approach. A total of 133 respondents (i.e., residents) were completed the questionnaire. The questionnaire taken 4-5 minutes to be completed. The survey approach is used as it is rationale to cover wide range of residential area.

A questionnaire was designed with 75 items which is consists of four main sections, section A is demographic question, section B is questions related to quality aspects, *n* = 45 items), Section C is related to performance aspects = 24 items, and section D is questions related to the economic aspects = 6 items). A detailed questionnaire is presented in Table 1.

Table 1. Initial construct and items.

Section	Construct	No. Item	Total
Section B (Quality Aspect)	1. Spatial (SP)	1 – 11	11
	2. Design and aesthetics (DE)	12 – 18	7
	3. Physical (PS)		
	4. Building Material (BM)	19 – 25	7
	5. Work Quality (WK)	26 – 38	13
		39 – 45	7
Section C (Performance Aspect)	6. Comfortable and well -being CW)	46 – 52	7
	7. Environment and health (EH)	53 – 66	14
	8. Sustainability (ST)	67 – 69	3
Section D (Economy Aspect)	9. Value (VL)	70 – 72	3
	10. Cost (AC)	73 – 75	3
		Total	**75**

The findings of the research are discuss based on the objective, to determine whether POE items measurement can be used and has acceptable psychometric based on Rasch analysis. Rasch analysis is conducted based on primary assumptions on reliability index and separation index. Table 2 presents the analysis that used to determine the reliability for the questionnaire design. The quick measurement model measured the ability of each respondent to identify the difficulty of the questionnaire [19].

Table 2. Item functionality testing and examination in the Rasch measurement model.

No.	Testing and examination	Value accepted
1	Item-respondent reliability	> 0.80
2	Item-respondent division	> 2
3	Item Polarity: i. (PTMEA CORR.)	+ve PTMEA
4	Item suitability to measure construct: i. (MNSQ)	0.6 < MNSQ < 1.4
5	Standard residual correlation	< 0.70

4. Results and Discussion

A total of 133 respondents were completed the questionnaire survey, and 89% of response rate is obtained. According to analysis performed using Winsteps software with the Rasch Model approach, item testing and examination are performed based on aspects of reliability, item-responder isolation, detect polarity of items that measure constructs according to PTMEA CORR values, suitability of the building measuring item, and determining the subject items based on standardized residual correlation values. The following are the specifications for each test and the item's functionality.

4.1. Reliability and separation of item-respondents

This instrument's reliability can be determined by interpreting the values of Alpha Cronbach from 0.00 to 1.0. If the range value is close to 1.0, it means that the reliability level is in good shape and has a high degree of consistency. The range approaches 0.00, indicating a poor level of reliability Cronbach's Alpha interpretation table score is shown in Table 3 [20].

Table 3. The score table of Alpha Cronbach.

Alpha Cronbach Score	Level of Reliability
0.8 – 1.0	Very good and high degree of consistency
0.7 – 0.8	Good and can be accepted
0.6 – 0.7	Can be accepted
< 0.6	Items need to fix
< 0.5	Items need to be eliminated

Reliability and separation index

Table 4 presents the finding for reliability and separation index, which is individual ability obtained was 0.83. This finding is considered good and acceptable within the range of 0.81 to 0.90 as suggested by Arnold et al. [21]. The findings illustrated that the person separation index is acceptable to acquire a high reliability value. Table 4 also indicates the construct reliability score of 0.82 and the isolation value of 2.10 for the respondents.

Table 4. Statistical summary for person.

Testing	Raw Score	Count	Measure	Model Error	*Infit*		*Outfit*	
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	244.7	75.0	.32	.14	1.00	-.1	1.01	-.1
Standard Deviation	17.6	.0	.34	.00	.32	1.9	.34	1.9
Max.	288.0	75.0	1.15	.15	2.65	2.65	2.81	7.8
Min.	200.0	75.0	-.59	.14	.50	-4.0	.47	-3.9

Real RMSE	0.15	True SD	.30	Separation	2.10	Person Reliability	.82
Model RMSE	0.14	True SD	.31	Separation	2.25	Person Reliability	.84
S.E. of Person Mean = .04							

Besides, Table 5 shows a reliability index of 0.94 for each item, with a separate index of 4.07 for each of 75 sub-constructs. The results show that the repeatability of these 75 sub-construction items is strong when given to additional groups of respondents with similar abilities [21].

Table 5. Statistical summary for item.

Testing	**Total Score**	**Count**	**Measure**	**Model Error**	***Infit***		***Outfit***	
					MNSQ	**ZSTD**	**MNSQ**	**ZSTD**
Mean	434.0	133.0	.00	.11	1.00	.0	1.01	.1
Standard Deviation	32.5	.1	.46	.01	.08	.7	.09	.8
Max.	523.0	133.0	2.30	.18	1.28	3.3	1.36	3.6
Min.	352.0	133.0	.81	.07	.84	-1.6	.83	-1.6
Real RMSE	0.11	True SD	.45	Separation	4.07	Item Reliability		.94
Model RMSE	0.11	True SD	.45	Separation	4.14	Item Reliability		.94
S.E. of Item Mean = .05								

4.2. Item of Polarity via PTMEA CORR value

The purpose of examining the Point Measurement Check (PTMEA CORR.) value is to identify polarity items and assess the construction's ability to accomplish the objectives. If the PTMEA CORR value is positive (+), the items being measured are in the correct construct [21]. Next, if obtained value is negative (-), it means that the item in the correct construct was not measured. If the item does not properly address the question or is difficult for respondents to answer, it must be updated or removed. Refers to the value of PT Measure Corr. in Table 6, there were two items at negative values (-), first items are PK8 (-0.01), and the second item is PK7 (-0.02). As a result, these two items have proposed to eliminate from the list of POE sub-constructs instruments.

Table 6. The value of PTMEA CORR.

Entry No.	**Point Measure Corr.**	**Item**	**Entry Number**	**Point Measure Corr.**	**Item**	**Entry No.**	**Point Measure Corr.**	**Item**
69	0.01	ST3	3	0.26	AR3	25	0.46	PS7
39	0.09	WK1	33	0.32	BM8	10	0.32	AR10
62	0.25	EH10	70	0.22	VL1	11	0.32	AR11
14	0.18	DE3	45	0.13	WK7	47	0.33	CW2
41	0.31	WK3	34	0.34	BM9	18	0.20	DE7
50	0.23	CW5	13	0.23	DE2	7	0.30	AR7
71	0.20	VL2	51	0.26	CW6	15	0.15	DE4
63	0.21	EH11	74	0.09	AC2	30	0.46	BM5

Entry No.	Point Measure Corr.	Item	Entry Number	Point Measure Corr.	Item	Entry No.	Point Measure Corr.	Item
65	0.26	EH13	12	0.33	DE1	16	0.26	DE5
52	0.26	CW7	24	0.48	PS6	27	0.43	BM2
32	0.10	BM7	57	0.22	EH5	59	-0.02	EH7
61	0.30	EH9	17	0.30	DE6	35	0.38	BM1
20	0.13	PS2	29	0.53	BM4	42	0.34	0
64	0.25	EH12	49	0.18	CW4	54	0.23	WK4
19	0.26	PS1	5	0.45	AR5	46	0.31	EH2
72	0.06	VL3	4	0.27	AR4	31	0.26	CW1
66	0.26	EH14	56	0.29	EH4	55	0.23	BM6
68	0.07	ST2	58	0.28	EH6	23	0.50	EH3
38	0.54	BM1	60	-0.01	EH8	1	0.21	PS5
2	0.26	3	26	0.55	BM1	9	0.25	AR1
40	0.14	AR2	53	0.28	EH1	21	0.30	AR9
43	0.18	WK2	28	0.46	BM3	8	0.40	PS3
48	0.15	WK5	22	0.36	PS4	6	0.38	AR8
67	0.02	CW3	37	0.54	BM1	75	0.06	AR
44	0.38	ST1	36	0.36	2	73	0.14	AC3
		WK6			BM1			AC1
					1			

4.3. The suitability of item to measures the construction

The MNSQ (Mean-Square Outfit Index) may be used to identify whether an object is suitable for measuring construction. The MNSQ Outfit value should be between 0.6 and 1.4, according to Bond et al. [20], in order to guarantee that the item created is suitable for construction measurement. The item is misleading if the obtained value exceeds 1.4. Even though the score is less than 0.6, it shows that the respondent predicts the item far too easily. The ZSTD outfit value should also be between -2 and +2 [20]. The ZSTD index can be omitted if the MNSQ outfit amount is acceptable [20]. Therefore, the item may be dropped or corrected if this condition is not fulfilled.

The five highest MNSQ values and five lowest MNSQ values are presented in Table 7. The maximum value obtained was 1.36, whereas the lowest value was 0.95 in accordance with the table. These findings demonstrate that all items range from 0.6 to 1.4, indicating that all items are adequate for construction measurement.

Table 7. The Suitability table of items for measuring the construction.

ENTRY NO.	MEASURE	INFIT		OUTFIT		PT-MEASURE	ITEM
		MNSQ	ZSTD	MNSQ	ZSTD		
68	0.30	1.28	3.3	1.36	3.6	A .07	ST2
67	0.17	1.11	0.6	1.27	1.3	B .02	ST1
59	-0.36	1.16	1.3	1.15	1.2	C -.02	EH7
60	-0.19	1.15	1.2	1.14	1.2	D -.01	EH8
32	0.47	1.13	1.2	1.14	1.2	E .10	BM7
23	-0.40	0.87	-1.2	0.87	-1.2	e .50	PS5
29	-0.10	0.85	-1.3	0.85	-1.2	d .53	BM4
37	-0.23	0.84	-1.5	0.84	-1.5	c .54	BM12
38	-0.29	0.84	-1.6	0.84	-1.6	b .54	BM13
26	-0.20	0.84	-1.4	0.83	-1.4	a .52	BM1

4.4. Standard correlation values

Table 8 presents the items that dependently from other parts. The parts of the data not explained by the Rasch model are known as residuals. The presence of a high correlation between the residuals of two items (or people) suggests that they are not locally independent, either because they duplicate some attribute of each other or because they both include some other shared dimension. In this Table, high positive residual correlations may indicate local item dependency (LID) between pairs of items. The item is overlapping rather than solitary if the residual correlation value is greater than 0.7. If the correlation values of two things surpass 0.7, only one item is required and maintained. Item selection refers to an MNSQ value, with values close to 1.00 being preserved [21]. Table 8 shows that no item has a correlation value larger than 0.7. Therefore, there is no overlapping items found in this study.

Table 8. Largest standardized residual correlation (items)

Correlation	Entry No	Item	MNSQ	Entry No	Item	MNSQ
0.64	73	AC1	1.05	75	AC3	1.09
0.63	9	AR9	1.01	10	AR10	1.00
0.60	74	AC2	1.12	75	AC3	1.09
0.57	64	EH12	1.03	65	EH13	0.98
0.57	16	DE5	0.99	28	BM3	0.88
0.55	24	PS6	0.89	28	BM3	0.88
0.53	28	BM3	0.88	29	BM4	0.85
0.52	5	AR5	0.94	6	AR6	0.98
0.52	7	AR7	1.03	8	AR8	0.94
0.51	25	PS7	0.90	29	BM4	0.85

Following a review and testing of the item's functionality, an evaluation of each item generated using the standard index and the Rasch Measurement Model's requirements for the instrument's validity and reliability is carried out. Experts are called in to remove the items. As a result of the pilot study, two items did not meet the analysis requirements and were eliminated. While the 73 items were retained under the expert's consent. Based on data analysis, the summary of items is on Table 9. Based on the analysis findings, two items eliminated from the list because of dubious reliability.

Table 9. The final items of POE instrument.

No	Dimension	Item	No item	Eliminated Item	Remain Item
1	Space analysis	AR1, AR2, AR3, AR4, AR5, AR6, AR7, AR8, AR9, AR10, AR11	11	0	11
2	Design and aesthetic	DE1, DE2, DE3, DE4, DE5, DE6, DE7	7	0	7
3	Physical	PS1, PS2, PS3, PS4, PS5, PS6, PS7	7	0	7
4	Building material	BM1, BM2, BM3, BM4, BM5, BM6, BM7, BM8, BM9, BM10, BM11, BM12, BM13	13	0	13

No	Dimension	Item	No item	Eliminated Item	Remain Item
5	Work quality	WK1, WK2, WK3, WK4, WK5, WK6, WK7	7	0	7
6	Environment and health	EH1, EH2, EH3, EH4, EH5, EH6, EH7, EH8, EH9, EH10, EH11, EH12, EH13, EH14	14	2 (EH7) (EH8)	12
7	Comfortable and well-being	CW1, CW2, CW3, CW4, CW5, CW6, CW7	7	0	7
8	Sustainability	ST1, ST2, ST3	3	0	3
9	Value	VL1, VL2, VL3	3	0	3
10	Cost	AC1, AC2, AC3	3	0	3
	Total		**75**	**2**	**73**

5. Conclusions

This paper aims to determine whether the constructed POE item measurement can obtain good psychometric properties in the context of the IBS high-rise residential. This study has found that 73 items are able to fulfil the requirement of good psychometrics measurement. Therefore, the design and development constructed items in POE can be used to collect real data. The Rasch model is a one of the significant analysis tools to confirm the usability of the instrument development.

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