

Confirmation of E-Waste Sustainable Management Instrument in the Community

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Abstract

This article aims to build instruments for the purpose of measuring sustainability of e-waste management in the community. For the purposes of testing the validity and reliability of e-waste sustainability management tools in the community, Exploration Factor Analysis (EFA) and Validation Factor Analysis (CFA) are used. The respondents were 500 people from nine districts in Selangor. Sample selection is by district, based on cluster sampling according to population size and selection of respondents is made using simple random sampling method. The Exploratory Factor Analysis (EFA) was conducted after the data was obtained and the item removal and repair process was done to form the study construction. Data were analyzed using Confirmatory Factor Analysis (CFA) and reliability analysis. The results showed that the three main constructs of the study were the knowledge, attitude and practice of e-waste disposal. There are four sub-constructs for knowledge and practice of waste disposal i.e. environment, social, health, and economy. While for the construction of e-waste disposal it consists of two sub constructs, namely environment and economy. The reliability value obtained is greater than 0.7 for all tested constructs. The implications of the study suggest that knowledge, attitude, and e-waste disposal practices need to be applied in communities that manage e-waste sustainably.

Keywords: Sustainability Management, E-Waste, Community, Exploratory Factor Analysis (EFA), Validation Factor Analysis (CFA)

Introduction

Technological advances, especially the development of electrical and electronic equipment technology are growing in Malaysia and contribute positively to human life. However, the ultimate issue is how unusable or unneeded electrical and electronic equipment, which is termed as e-waste, should be properly managed to ensure environmental sustainability. It has even been proven that e-waste has tripled more rapidly today than in previous years (Puckett et al., 2002; United States Environmental Protection Agency (U.S. EPA), 2011). An estimated 20 to 25 million tons of e-waste are generated annually worldwide (Abul Hassan et al., 2010). The amount of e-waste will continue to increase from year to year in line with technological developments (Ibitz, 2012; Robinson, 2009).

In Malaysia, e-waste management is still in its early stages including the e-waste recycling system (Faisal et al., 2014; Junaidah, 2010). The main problem faced by Malaysia's e-waste challenge is the attitude of Malaysians to low residual e-waste recycling (Ho et al., 2015; Junainah, 2010). Similarly, there are still many deficiencies in terms of management and disposal mechanisms of this material while the use of electrical and electronic equipment is increasing in tandem with the increase in the population. The management of solid waste including e-waste in Malaysia, at the present time, is very challenging and is often a national issue (Abdul Rahman, 2008). E-waste management facilities for more sustainable sources should be addressed (Fatimah et al., 2014). Most of the landfill sites in Malaysia now have an increasingly diminishing lifetime. This is due to the volume of solid waste generation including e-waste which increases in tandem with the increase in population. In fact, the shorter life of electrical and electronic products has increased the accumulation of e-waste in Malaysia. This electrical and electronic equipment contains hazardous toxins (such as lead, mercury, and cadmium) which, when released into the environment, may pollute water, soil, and air. Electronic waste also contains polychlorinated biphenyls (PCBs) which can cause carcinogenic effects in humans and can be harmful to human health (Muaz & Mohamed, 2008). The issue in the context of e-waste disposal is a relatively complex management system and is different from managing routine solid waste. In Malaysia, electronic waste must comply with the Environmental Quality Act 1974 enacted by the Department of the Environment. Electronic waste is categorised as scheduled waste under the SW 110 code managed by the Department of the Environment. This means that the e-waste must not be disposed of along with other solid waste.

The question is how much people really know about how to manage e-waste the right way to ensure the preservation of the environment, for example in the state of Selangor. Selangor has provided e-waste recycling space and arranged for the dissemination of e-waste information through the Department of Environment and other non-governmental agencies. Therefore, this study looks at the level of Malaysian society practice in managing e-waste by taking Selangor as a benchmark. The collection of information on the community's knowledge, attitudes, and practices in managing e-waste is a necessity in improving the dissemination of information and also examining the real constraints on the community in implementing more sustainable e-waste management.

Literature Review

Economic growth, industry and technology have made Malaysia a market for electronic tools with new products, brands, and a wide choice of models. Technological advances, especially the development of electrical and electronic equipment technology are growing in Malaysia and contribute positively to human life. However, the ultimate issue is how unused or unneeded electrical and electronic equipment, which is termed as e-waste, should be well managed to ensure environmental sustainability. It has even been proven that e-waste has risen three times faster today than in previous years (Puckett et al., 2002; U.S. Environmental Protection Agency (USEPA), 2011). An estimated 20 to 25 million tons of e-waste is produced each year worldwide (Abul Hasan et al., 2010) and the amount of e-waste will continue to increase year after year in line with technological developments (Armin, 2012; Robinson, 2009). E-waste generation in Malaysia is increasing in various industry sources as well as in the industrial sectors. E-waste generated from non-industrial sectors including commercial entities such as banks, laundries, restaurants, offices, and households is not well regulated

under current regulations. As a result, most of the e-waste will end up in improper recycling methods and informal method. E-waste handling with incorrect recycling methods can also lead to the risk of pollution and health hazards. For example, refrigerated gas contained in refrigerators or air conditioners is released into the air and causes global warming and ozone depletion. This means that the termination of the lifetime of the electrical and electronic equipment should be managed using the correct method.

Research on individual awareness of e-waste management practices plays an important role in ensuring that individuals understand and know, or do not know, about managing e-waste. By definition, consciousness is an understanding of other activities in the context of self-activity (Dourish & Bellotti, 1992). However, according to Starke (1990) many people fail to translate consciousness into commitment and there are many individuals who have knowledge and awareness about the environment but still have an irresponsible attitude towards the environment. In the context of this study, the awareness of e-waste management in the community covers three main elements, namely knowledge, attitude, and practice based on the preliminary model of pro-environmental behaviour introduced by Kollmuss and Agyeman (2002). This model covers environmental knowledge, attitudes towards the environment and pro-environmental behaviours. Consequently, awareness elements, attitudes, and practices towards e-waste management are important in creating cost-effective and environmentally-friendly management systems as stated by (Norazli et al., 2015).

Studies in several countries such as Jordan, Nigeria, India, China, Spain, Iraq, and the Philippines have revealed that the level of community knowledge on e-waste management is different in some areas. For example, in Tawawneh and Saidan's (2013) study in Jordan, the level of household knowledge on e-waste is low and almost all respondents do not know about e-waste. In addition, the study of Okoye and Odoh (2014) in Onitsha, West Africa) also demonstrates that knowledge of government e-waste management regulations and the harmful effects of electronic content on the health of the population is still low. This is worrying as Onitsha is the largest market for new electronic goods importers and supplier to West Africa.

Nevertheless, not all countries show low awareness of e-waste knowledge among their communities. For example, in the Ningbo area of China, most respondents have knowledge of e-waste management i.e. from the recycling aspect and 64% of respondents are familiar with environmental labelling. This is evident when consumers discard electronic waste, the consumer segregates the material according to the labelled waste (Huang et al., 2006). Although the studies of Okoye and Odoh (2014); Sivathanu (2016) show that users have knowledge of e-waste management, it has been found that when user understanding is tested in depth, most respondents are not able to provide the correct image and example.

Most studies show that the Malaysian community has a high level of knowledge on e-waste but when asked more about the management of e-waste, the Malaysian community's knowledge or understanding of e-waste management is found to be unsatisfactory. This can be seen from the studies of Rafia et al (2012); Rulia et al (2014) in the city of Kuala Lumpur, where the findings show that respondents know that electrical and electronic equipment have created problems in the environment. The Junaidah study (2010) on the level of

knowledge and awareness of the community in Shah Alam also indicates that respondents have high knowledge of e-waste. However, researchers found that most respondents did not know how to dispose of e-waste. This statement was also supported by Nur Sumaiyyah et al (2015) who state that consumers are not aware of the proper way to treat e-waste even though local authorities such as those in Selangor have implemented solid waste separation from 1 September 2015 under the regulations of the Solid Waste Management and Public Cleansing Act 2007 (Act 672) (National Solid Waste Management Department, 2015).

Methodology

Research location

The location of the survey is to involve the consumer community living in Selangor. Selangor consists of nine districts, namely Petaling, Hulu Langat, Klang, Gombak, Kuala Langat, Sepang, Kuala Selangor, Hulu Selangor and Sabak Bernam. The selection of Selangor as a study area is due to the increasing exposure to e-waste through government and private agencies. This means that the Selangor community has been given information and awareness earlier than people in other states. For this reason, Selangor is seen as an appropriate state to examine knowledge of e-waste, attitudes, and practices of e-waste management in its community.

Population and Sample Studies

The sampling method used in this study involved layered random sampling for the study area and simple random sampling for the respondent selection by district in Selangor. The total population of the nine districts of Selangor is 3,947,527 (Department of Statistics Malaysia, 2010). Of these, the recommended minimum number of samples was 387 based on the Krejcie and Morgan (1971) tables. While to run factor analysis, Comrey and Lee (1992) give the following guide for samples sizes: 50 as very poor, 100 as poor, 200 as fair, 300 as good, 500 as very good, and 1,000 as excellent. Thus, this study sets the number of respondents as up to 500 people due to the removal of samples in the Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) processes. There are nine districts in Selangor and the number of respondents selected were come from the communities that live in the designated area. Respondents taken are those who are the heads of households. The breakdown of population numbers and sample respondents by district as shown as in Table 1.

Table 1

Number of respondents by district in Selangor

District	Population	Percentage (%)	Calculation of Sample	Sample
Petaling	1,181,034	30	30% x 500	150
Hulu Langat	865,514	22	22% x 500	110
Klang	648,918	16	16% x 500	82
Gombak	553,410	14	14% x 500	70
Kuala Langat	189,983	4	4% x 500	24
Selangor	97,896	3	3% x 500	12
Kuala Selangor	157,288	4	4% x 500	20
Hulu Selangor	142,771	4	4% x 500	18
Sabak Bernam	110,713	3	3% x 500	14
Total	3,947,527	100	500	500

The two main factor analysis techniques are Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). CFA attempts to confirm hypotheses and uses path analysis diagrams to represent variables and factors, whereas EFA tries to uncover complex patterns by exploring the dataset and testing predictions (Child, 2006). To determine the construction of the e-waste sustainability management that needs to be incorporated into this instrument, the EFA has been conducted to determine the construction and substructure of the e-waste sustainability management of the community. As a result, there are three main components of e-waste sustainability management, namely knowledge, attitude, and practice. The sub constructs for e-waste management knowledge are environmental, social, health related, and economic. The next consideration is reliability and validity constructs. The reliability test (Alpha Cronbach) and CFA have been implemented. The CFA is controlled on the measurement model based on the hypothesis factor using Analysis Moment of Structure (AMOS). To examine the correspondence of the measurement model having 61 items, the compatibility index such as: (i) the minimum value of the dispute between the observed data and the hypothesis model divided by degree of freedom (CMIN / df), (ii) Comparative Fit Index (CFI), (iii) Tucker Lewis Index (TLI), (iv) Incremental-Fit-Index (IFI) and (v) The Root Mean Square Error of Approximation (RMSEA). According to Arbuckle (1997); Hair et al (2006), stated that a model corresponds to the corresponding match index: (i) CMIN / df with a value between 1 and 5 is considered acceptable fit for models and data; (ii), the CFI, IFI and TLI indexes approaching 1.00 show an appropriate match; and (iii) the RMSEA .08 or less index indicates a reasonable and acceptable estimate of error.

Next, the construct validity is done to solidify the hypothesis constructed position. Construct validity involves convergent and discriminant validity. Centralised validity was assessed based on the research on the coefficients of each loading item significantly ($p < 0.05$) and the reliability of the composite for a latent variable (Anderson & Gerbing, 1988; Fornell & Larcker, 1981). The value of composite reliability exceeding 0.70 indicates the centralisation of the firm is in a good position (Fornell & Larcker, 1981; Hair et al., 2006). Meanwhile, discriminant validity is assessed by comparison between squared correlations between two constructs with average variance extracted respectively. If the average variance is quoted above the square correlation, the discrimination validity is reached (Fornell & Larcker, 1981).

Result

Reliability

The reliability scale test (Alpha Cronbach) is carried out to obtain the internal consistency of the variable. In this study, all the values of internal consistency (Alpha Cronbach) for all variables exceeded 0.7. According to Babbie (1992), Alpha Cronbach values are classified into four categories i.e. 0.90 – 1.00 is very high, 0.70 – 0.89 is high, 0.30-0.69 is moderate and 0.00 – 0.30 is low. Therefore, the results of the analysis in the study show the Alpha Cronbach values for all variables in the high classification (Table 2).

Table 2

The Reliability Value of the Actual Study

Contract	Sub Contract	Number of Items	Number of Items Aborted	Alpha Cronbach Value
E-waste Management Knowledge	Environment	7	2	0.770
E-waste Management Knowledge	Social	9	1	0.881
E-waste Management Knowledge	Economy	6	0	0.857
E-waste Management Attitude	Environment	5	0	0.762
E-waste Management Attitude	Social	7	2	0.766
E-waste Management Attitude	Economy	5	0	0.754
E-waste Management Practices	Environment	9	1	0.818
E-waste Management Practices	Social	6	0	0.849
E-waste Management Practices	Economy	7	3	0.721

Analysis of Exploration Factor (EFA) and Factor Analysis of Knowledge Constructs of E-waste Management Knowledge

The Exploratory Factor Analysis (EFA) results on the community e-waste management knowledge measurement tool describe the anti-image correlation analysis procedure showing the value of the coefficient of the correlation is greater than 0.5 and this gives the impression that factor analysis can be continued. Measurement adequacy of Kaiser-Meyer-Olkin sampling (KMO) and Bartlett's Test of Sphericity showed that the KMO value was 0.904, while the Bartlett's Sphericity test was significant with the Chi-squared score of 5788.704 at the 231 degree of freedom.

Table 3

The suitability test for the use of factor analysis and uniformity of KMO and Bartlett's Test item on the development of e-waste management knowledge

<i>Kaiser-Meyer-Olkin</i>	<i>Measure of Adequacy</i>	<i>Sampling</i>	0.904
<i>Bartlett's Test of Sphericity</i>	<i>Approx. Sphericity</i>	<i>Chi-Square</i>	5788.704
	<i>df</i>		231
	<i>Sig.</i>		0.000

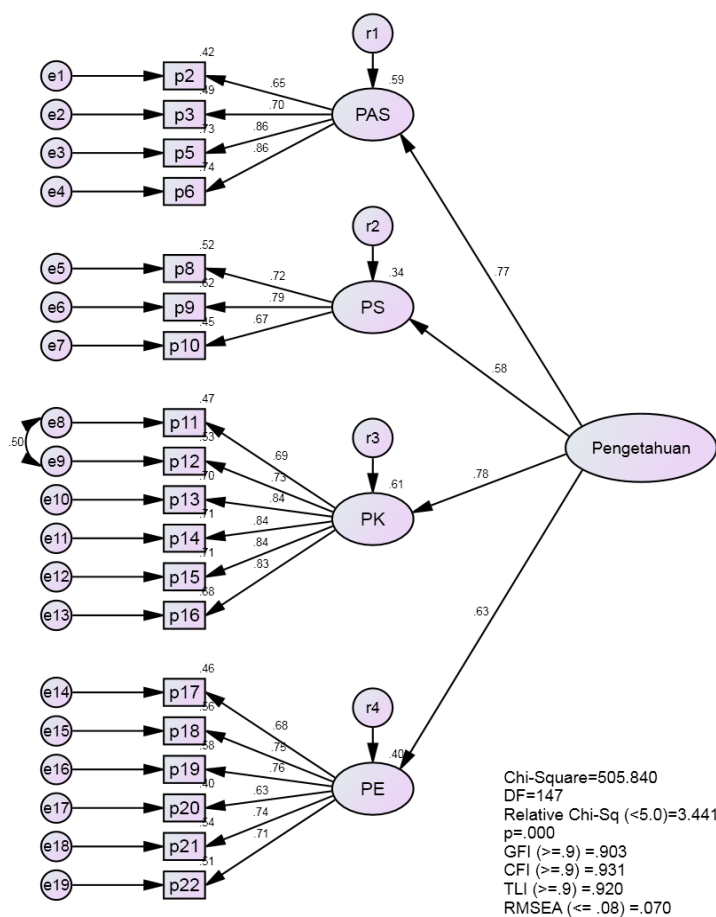
Factor analysis was done by the researcher to determine the number of factors to be extracted into four as categorised in the questionnaire. Table 4 shows the component matrix with varimax rotation. The varimax rotation method is performed as it reduces the amount of complex constructs and increases the expected yield. The results show that the items of p4 and p7 have been dropped because they have an 'anti-image correlation matrix' of less than 0.5. While the values of p1, p2, p3, p5 and p6 belong to component 1, that is the environment, p8, p9 and p10 stacked in component 2, social, p11, p12, p13, p14, p15 and p16 accumulated in component 3 i.e. health and p17, p18, p19, p20, p21 and p22 belong to the 4th group which is the economy. The value shown in Table 4.10 is the coefficient or the load factor for each item that leads to each factor being stacked. This value shows the correlation bond between the item and the factor that is formed and it is the key to understanding the nature of these factors. Furthermore, the CFA analysis is conducted to confirm the results obtained from the EFA analysis.

Table 4

Component matrix with varimax rotation construct e-waste management knowledge

Items	Component			
	Environment	Social	Health	Economy
p1	.727			
p2	.710			
p3	.782			
p5	.734			
p6	.721			
p8		.729		
p9		.869		
p10		.734		
p11			.734	
p12			.753	
p13			.792	
p14			.814	
p15			.827	
p16			.796	
p17				.652
p18				.736
p19				.789
p20				.635
p21				.793
p22				.745

Furthermore, the Validation Factor Analysis (CFA) is carried out using the AMOS 20 software to determine the first and second level validation factor analysis model of the e-waste management knowledge. Figure 1 shows the second stage CFA model of the knowledge management of e-waste that has achieved good matching accuracy. This model is a combination of all the dimensions of the knowledge management of e-waste maintained in the first level analysis.



Legend:

- PAS : Environmental Knowledge
- PS : Social Knowledge
- PK : Health Knowledge
- PE : Economy Knowledge
- Pengetahuan : E-waste Management Knowledge

Figure 1 Model analysis of second-level validation factor of e-waste management knowledge

Based on the model being developed in Figure 1, the model has achieved a good level of compatibility based on the set guidelines (CMIN = 505.840, DF = 147, CMIN/DF = 3.441, p = .000, GFI = .903, CFI = .931, TLI = .920, dan RMSEA = .070).

Exploration Factor Analysis (EFA) and Analysis Factor Confirming Community E-waste Management Attitude Construct)

The Exploratory Factor Analysis (EFA) results on the community e-waste management gauges tool describe the anti-image correlation analysis procedure showing the value of the coefficient of the correlation is greater than 0.5 and this illustrates that factor analysis can be continued. Measurement adequacy of Kaiser-Meyer-Olkin sampling (KMO) and Bartlett's Test of Sphericity showed KMO value was 0.863, while Bartlett's Sphericity test was significant with its Chi-squared value of 2884,799 in degree of freedom 136.

Table 5

The suitability test for the use of factor analysis and uniformity of the KMO and Bartlett's Test items on the e-waste management attitude construct

<i>Kaiser-Meyer-Olkin</i>	<i>Measure of Sampling Adequacy</i>	0.863
<i>Bartlett's Test of Sphericity</i>	<i>Approx. Chi-Square</i>	2884.799
	<i>df</i>	136
	<i>Sig.</i>	0.000

As with the knowledge management concept of e-waste, factor analysis is done by setting the number of factors to be extracted into two as categorised in the questionnaire. Table 6 shows the component matrix with varimax rotation. The varimax rotation method is performed as it reduces the amount of complex constructs and increases the expected yield. The results showed that the items s1, s2, s3, s9 and s12 were dropped because they had an 'anti-image correlation matrix' of less than 0.5. Whereas the s4, s5, s6, s7, s8, s10 and s11 values belong to component 1, the environment, and s13, s14, s15, s16 and s17 are accumulated in component 2, the economy. The value shown in Table 4.6 is the coefficient or the load factor for each item that tends to each factor that is stacked. This value shows the correlation bond between the item and the factor that is formed and it is the key to understanding the nature of these factors. Furthermore, the CFA analysis is conducted to confirm the results obtained from the EFA analysis.

Table 6

Component matrix with varimax rotation e-waste management attitudes constructs

Items	Component	
	Environment	Economy
s4	.593	
s5	.707	
s6	.552	
s7	.790	
s8	.768	
s10	.744	
s11	.787	
s13		.666
s14		.562
s15		.786
s16		.725
s17		.673

Validation Factor Analysis (CFA) is carried out to determine the first and second level validation factor analysis model of e-waste management attitudes. Figure 2 shows the second stage CFA model of the construction of e-waste management attitudes that have achieved good matching accuracy. This model is a combination of all construct dimensions of the e-waste management stance maintained in the first stage analysis.

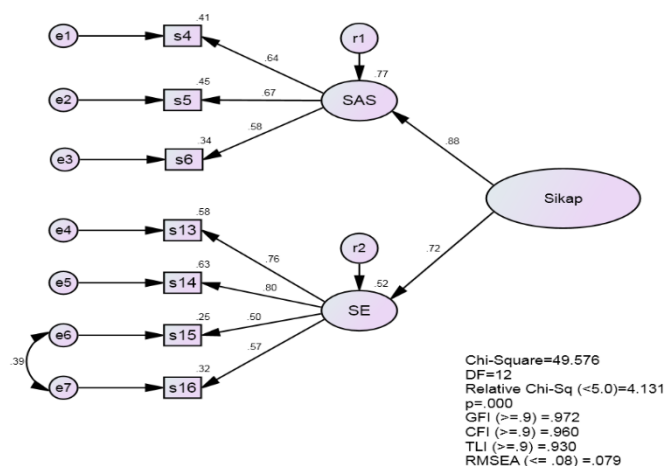


Figure 2 Model of Factor Analysis Model Second E-waste Management Attitude

Legend:

- SAS : Environmental Attitude
- SE : Economy Attitude
- Sikap : E-waste Management Attitude

The model analysis in Figure 2 shows that the model has reached a good level of compatibility based on the prescribed indication (CMIN = 49.576, DF = 12, CMIN/DF = 4.131, p = .000, GFI = .972, CFI = .960, TLI = .930, dan RMSEA = .079).

Analysis of Exploration Factor (EFA) and Factor Analysis of Constructs of Community E-waste Management Practice

The EFA's decision on the community e-waste management practices measure explaining the anti-image correlation analysis procedure shows that the value of the coefficient of the correlation is greater than 0.5 and this suggests that factor analysis can be continued. Measurement adequacy of Kaiser-Meyer-Olkin sampling (KMO) and Bartlett's Test of Sphericity showed that the value of KMO was 0.910, while the Bartlett's Sphericity test was significant with its Chi-squared value of 5062.996 at the degree of freedom 231.

Table 7

Appropriateness Test of Use Factor Analysis and Uniformity of KMO and Bartlett's Test Items on Construct of E-Waste Management Practice

<i>Kaiser-Meyer-Olkin</i>	<i>Measure of Adequacy</i>	<i>Sampling</i>	0.910
<i>Bartlett's Test of Sphericity</i>	<i>Approx. Sphericity</i>	<i>Chi-Square</i>	5062.996
	<i>df</i>		231
	<i>Sig.</i>		0.000

Factor analysis was done by the researcher to determine the number of factors to be extracted into four as categorised in the questionnaire. Table 4.8 shows the component matrix with varimax rotation. The varimax rotation method is performed as it reduces the amount of complex constructs and increases the expected yield. The results showed that the

items a5, a8, a11 and a22 were dropped because they had an 'anti-image correlation matrix' of less than 0.5. Whereas the values of a1, a2, a3, a4 and a6 belong to component 1, environmental, a9, a10, a16 and a17 stacked in component 2, social; a12, a13, a14 and a15 accumulated in component 3 namely education and a7, a18, a19, a20 and a21 belong to the 4th group, economics. The value shown in Table 4.8 is the coefficient or the load factor for each item that leads to each factor that is stacked. This value shows the correlation bond between the items and the factor that is formed and it is the key to understanding the nature of these factors. Furthermore, the CFA analysis is conducted to confirm the results obtained from the EFA analysis.

Table 8

Component matrix with varimax rotation e-waste management practices constructs

Items	Component			
	Environment	Social	Health	Economy
a1	.547			
a2	.644			
a3	.709			
a4	.594			
a6	.605			
a9		.514		
a10		.577		
a16		.751		
a17		.572		
a12			.576	
a13			.791	
a14			.828	
a15			.739	
a7				.548
a18				.673
a19				.694
a20				.707
a21				.719

Then the CFA is run again. Figure 3 shows the second stage CFA model of the construction of e-waste management practices that have achieved good matching accuracy. This model is a combination of all construct dimensions of e-waste management practices maintained in the first level analysis.

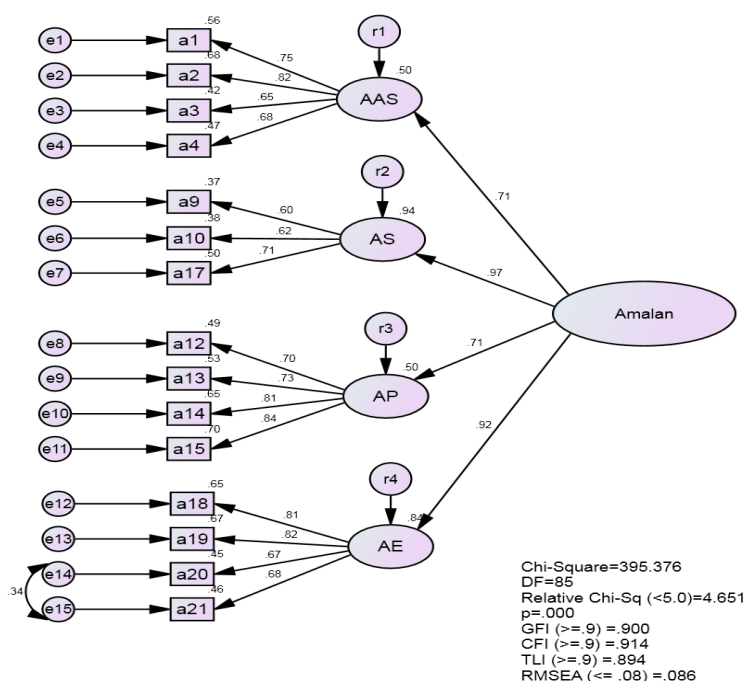


Figure 3 Model analysis of second-level validation factor of e-waste management practices

Legend:

- AAS : Environmental Practices
- AS : Social Practices
- AK : Health Practices
- AE : Economy Practices
- Amalan : E-waste Management Practices

The model analysis in Figure 3 shows that the model has reached a good level of compatibility based on the prescribed indication (CMIN = 395.376, DF = 85, CMIN/DF = 4.651, p = .000, GFI = .900, CFI = .914, TLI = .894, dan RMSEA = .086).

Discussion

The Facts Authentication Analysis (CFA) process for the validity and reliability testing of the e-waste sustainability management tool demonstrates that the construction of knowledge and practice of e-waste disposal involves four sub constructs namely environment, social, health, and economy while the construct of e-waste disposal attitude only involves two sub constructs namely environment and economy (Figure 4). This is in line with the theory introduced in the Pro-Environmental Preliminary Model (Kollmuss & Agyeman, 2002).

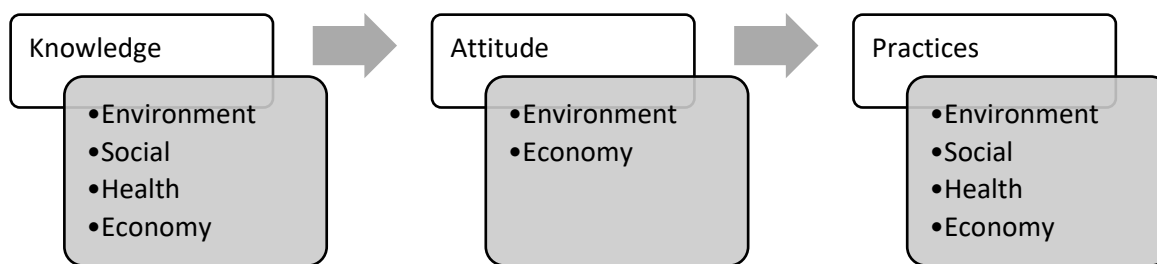


Figure 4 Constructs and sub constructs of studies

Conclusion

The strength of this e-waste sustainability management instrument shows that each item contributes to the measurement of each construct. All three constructs have a high construct validity which, when viewed at the value of RMSEA is ≤ 0.08 , which is acceptable for constructional constraints. CFI, IFI and TLI values are approaching 1 or ≥ 0.9 . This demonstrates that this instrument is sufficient to use at other times continuously on the characteristics of the same and nearly identical sample groups. The findings show that the burden factor shown for all 61 items is above 0.5. This shows that all 61 items of e-waste sustainability management measure three constructs that have been formed. The intention of this study is to build an instrument to measure how far the management of e-waste in a community is valid and reliable based on a robust CFA measurement model. The findings from an assessment can be used by relevant parties or researchers who are interested in studying the management of e-waste in the community in an area that involves aspects of knowledge, attitudes, and practices.

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