Developing a Structural Model to Assess Students' Knowledge-Attitudes towards Sustainability

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Abstract

The objective of this study is to develop a structural model to assess students' knowledge-attitude towards sustainability. It is focused on the first-year engineering students. A 36-item of initial questionnaire has been developed and distributed to 188 respondents during the study. The data are analyzed using Statistical Packages of Social Sciences (SPSS) Version 18 and AMOS 18. There are two stages of analysis; namely, confirmatory factor analysis and structural equation model. The use of structural equation model (SEM) has successfully developed a model of knowledge-attitude with the smallest necessary number of parameters that are able to still adequately describe the observed covariance structure. Results have shown that the structural model was reliable and in agreement with the influence of knowledge on attitude towards sustainability among the first-year engineering students. It was found that the basic knowledge on sustainable development has a strong correlation to developing and improving students' attitudes. The model has also successfully measured the level of knowledge and attitude before and after treatment process, why they required to understand sustainable development and how much they change their attitude towards sustainability. This model is also proposed as a tool for lecturers to prepare their teaching materials and emphasise the important elements of sustainable development that they have to address. As effective teachers, they should be professionally knowledgeable in sustainable development and capable of integrating it in related courses.

Keywords: Structural Equation Model, Confirmatory Factor Analysis, Sustainable Development;

1. Introduction

Nowadays, sustainable development is much emphasised at all levels of education in order to inculcate the awareness of sustainability to maintain and improve the quality of life in the present and future generations. Through lifelong learning, students would have the knowledge and skills to address and overcome the issues related to their environment, economy and social well being. It is especially essential to develop future engineers with the latest knowledge and technical skills with knowledge of sustainability. Therefore, the universities as higher education providers are the right place to reform and develop students' knowledge, skills and attitudes towards sustainability, because as problem solvers and innovators, they should play their crucial role in the development of the nation. The issues on sustainable development should be addressed in the learning process as early as the first year of study to ensure the graduates establish a responsibility to the environment, social and economic activities. A quality of life in the future will depend on the present society as it would have an authority in developing and managing the country.

However, looking into the Malaysian environmental scenario, several incidents have clearly indicated problems due to the imbalance development growth that can cause devastation to the environment and brought miseries to the people and landscape. Therefore, it is the shared responsibility of an academician, through proper curriculum design to instill awareness on all students with the intention that they can preserve the environment. Studies conducted on environmental awareness and lifestyles, showed that Malaysian have low to moderate level of understanding on environmental issues. For instance, Tamby et. al (2010) conducted a studied around the concept of environmental

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citizenship that gravitates around the Malaysian primary and secondary school students. The results show, students have low level of knowledge and attitude. Pauziah (2004) has embarked on a research on environmental education at primary school and she claimed that environmental education has never gravitated in addressing the interrelationships of components such as knowledge, attitude, skill and participation. While, several major problems defined as barriers in engineering education towards environmental for sustainability have listed as lack of awareness and appreciation of environmental issues between the academics and students, the academics are lacking knowledge and experiences on integrating environmental aspects into engineering education and had very little focus on environmental issues in the engineering curriculum. They are just experiencing the problem of environmental pollution, sewage disposal in rivers, open burning and haze problems but their knowledge and awareness are not up to the level to think about adverse long time effect of this problem on national economy and their life (Tamby et. al. 2010). There are several established instruments to measure environmental attitudes towards sustainability such as Children's Environmental Attitude & Knowledge Scale (Leeming et al, 1995), Environmental Attitude & Ecological Behaviour (Kaiser, 1999), Behaviour-Based Environmental Attitude (Kaiser, 2007) and New Environmental Paradigm (Dunlop & Van Liere, 1978).

Thus, the purpose of this study is to develop a structural model of assessing students' knowledge-attitude towards sustainability among the first year engineering students. The use of structural equation model (SEM) has been successfully developed on a model of knowledge-attitude with the smallest necessary number of parameters that still adequately describes the objectives of the study. Through teaching and learning activities, students are exposed to sustainability issues. This model can be used as a tool to determine the level of students' knowledge and attitude towards sustainability before and after they have enrolled into the course. Based on this model, the influence of knowledge in improving and developing students' change of attitudes towards sustainability could be determined.

2. Literature Review

The definition for Education for Sustainable Development of ESD provided by the Sustainable Development Education Panel of the United Kingdom (September 1998), states that "Education for sustainable development enables people to develop knowledge, values and skills to participate in decisions about the way we things individually and collectively, both locally and globally, that will improve the quality of life now without damaging the planet for the future". In other words, ESD can be defined as the learning required to maintaining and improving the quality of life of the present and future generations, and education is used as a tool to achieve sustainability. In addition, giving students knowledge and skills for lifelong learning would help them find new solutions to their environmental, economic and social issues, as quoted from Chapter 36 of Agenda 21, Rio Declaration 1992. If students understand sustainability as an aspect of their social and ethical responsibility, they will become citizens who see themselves as connected to the natural world and to other humans. Thus, they will have the capacity to facilitate the development of activities that sustain rather than degrade.

Many research studies on the relationships between knowledge and attitude, such as Sheppard (2008) and Segalas (2009) indicated that graduates should be aware of sustainability issues. Therefore, their environmental attitude and behaviour could change by enhancing knowledge and awareness about environmental problems. According to the Theory of Planned Behaviour developed by Ajzen & Fishbein (1988), attitude is a function of belief, where beliefs refer to knowledge. This finding has been supported in social learning theories, saying that attitude and behaviours are learnt through our interactions with the social world in which we live (Albert Bandura).

First-year students enter university with multiple personal backgrounds, educational levels and perceptions. Prior research has shown that students' attitudes change over the course of their first academic year (Besterfield-Sarce et. al. 1994, 1995). They believed that these changes can be affected by the type and quality of educational programme that the students experienced. Therefore, it is important to instil the knowledge and understanding towards the awareness of sustainable development from the early year of study, that will be built and strongly embed in their cognitive and affective outcomes (attitude) in the way to be a future sustainability engineers. First-year stage is a very important year to educate future engineers by shaping their understanding of what content (knowledge and skills in context) future engineers must possess; how content should be learned; how learning of the content should be designed; how to engage in learning activities; and how to help them engage more effectively (Erickson, 2006).

2.1 Development of Initial Instrument

The initial instrument consists of two scales of knowledge and attitude. Knowledge is divided into two subscales, namely topics and basic knowledge about sustainable development. Items of knowledge are determined from a qualitative study using interviews with first year engineering students (Sharipah et al, 2012). Topic consists of 12 items related to current issues on sustainability and basic knowledge consists of 6 items from course objectives. While, attitude is consists of two subscales; namely pro-self (11 items) and pro-social (7 items). Pro-self is defined as a personal development that influences the way students interact with their environment and others (Moreno. R, 2010). Pro-social is a matter of wanting to help, caring relationships, contribution and being respectful of others. Items of the subscales are selected from established instruments to measure environmental attitude.

3. Methodology

The purpose of this study is to develop a structural model to assess students' knowledge-attitude towards sustainability for first-year engineering students. A mixed research methodology is used where the qualitative method triangulates within the quantitative one. The qualitative study is carried out to investigate the levels of knowledge and attitudes towards sustainability issues. Several questions, ideas, issues and perspectives have been identified and used to model the instrument. Quantitative study has been conducted as a second stage of this study by using the initial instrument from the first stage to evaluate the significance of items of each subscale. Therefore, this paper will focus and describe in detail the development of questionnaire as an instrument. Figure 1 shows the flow plan of the research methodology.

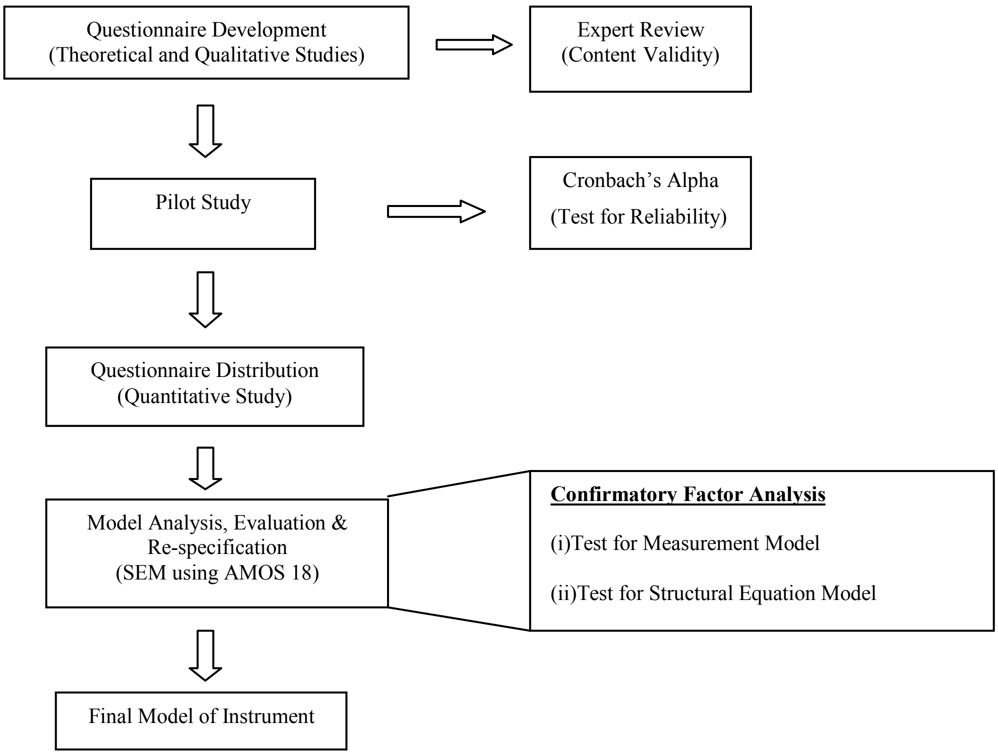

Figure 1: Flow Plan of Research Methodology

Structural Equation Model (SEM) using Analysis of Moment Structures (AMOS version 18) has been selected as the statistical technique for this study to investigate the influence of knowledge on developing and improving students' attitude towards sustainability. Structural equation model encompasses such diverse statistical techniques as path analysis, confirmatory factor analysis, causal modelling with latent variables, and even analysis of variance and multiple linear regressions. Theoretically, structural equation model (SEM) comprises of two types of models; a measurement model and a structural model. A measurement model is a confirmatory factor analysis (CFA) model in which there is the unmeasured covariance between each possible pair of latent variables, using goodness of fit measures. The AMOS 18 with maximum likelihood estimation is used to estimate the confirmatory and structural equation models in this study.

3.1 Design of Structural Model of Knowledge-Attitude

Figure 2 shows an initial structural model of assessing students' knowledge-attitude towards sustainability, developed from two measurement model of knowledge and attitude. A measurement model of knowledge consists of twelve (12) items on current topics about sustainable issues and six (6) items of basic knowledge on sustainability based on course objectives. Students are required to rate their level of knowledge according to 5 Likert-type scales; 1 – never heard of, 2 – heard of but cannot explain, 3 – know and can explain briefly, 4 – know and can explain in detail, 5 – expert and confidently talk to others. While, a measurement model of attitude consists of their pro-self and pro-social of sustainable lifestyle. Students are required to indicate their level of agreement on eleven (11) items on pro-self and seven (7) items on pro-social, according to 5 Likert-type scales; 1 – never, 2 – rarely, 3 – sometimes, 4 – often and 5 – always.

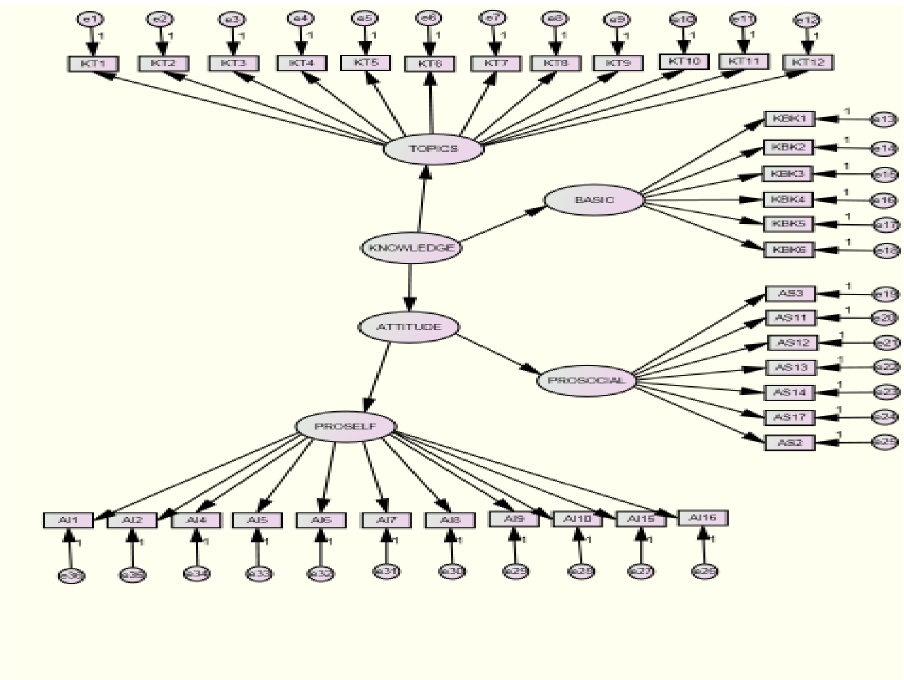

Figure 2: Illustration of Structural Model of Assessing Students' Knowledge-Attitude towards Sustainability

4. Result and Analysis

4.1Descriptive Result

A total of 188 first year engineering students, taking 'Introduction to Engineering' course and learned something on sustainability as part of the course content participated in the research study. During the semester, respondents have also been exposed to sustainability issues through several teaching and learning approaches such as lecturing, problem-based learning, poster presentation and competition. They are required to answer the same questionnaire at the beginning and end of the semester. The composition of respondents was composed of 47.9% males and 52.1% females. 43.1% of the respondents said that they have previously received some early education on sustainability, while 51.5% said that they received education on sustainability at higher education level or university. The reliability coefficients of Cronbach Alpha were used to test the reliability of the scale and the internal consistency of the questionnaire. This is presented in Table 1. From the statistical perspective, this is a reliable result as it exceeds 0.70 (Nunnally, 1978). Therefore, none of the items were deleted due to reliability concerns.

Table 1: Reliabilities and Number of Items

Subscale	Items	Cronbach Alpha
Topics	12	0.909
Basic	6	0.887
Pro-self	11	0.885
Pro-social	7	0.904

4.2 Model Evaluation and Analysis

The model was analysed using two stages of analysis, namely the Confirmatory Factor Analysis (CFA) and Structural Equation Model (SEM).

4.2.1 Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) was used to analyse the initial measurement model of knowledge-attitude. The primary goal of CFA was to evaluate the factor scale within a measurement model and to determine how well the measurement model fits to the data (Bollen, 1989). The two-step modeling approach suggested by Anderson and Gerbing (1988) was adopted. The first step of a measurement model allowed all latent scales to be correlated freely and all non-significant correlation values were removed. There were two types of measurement models: 1) first order measurement model, and 2) higher or second order measurement model. The second step of a structural analysis was designed to test relationships among latent variables.

4.2.2.1Confirmatory Factor Analysis of First-order Measurement Model of Knowledge-Attitude

Knowledge consists of two subscales, namely topics on sustainable issues and basic knowledge of sustainability. Table 2 shows the result of a statistical test of initial first-order measurement model of knowledge and attitude. The result of CFA, using path analysis showed the combinations of all subscales, excluding pro-self, did not comply with an acceptable limit of goodness of fit. Therefore, this initial first-order measurement model should be re-adjusted or trimmed to achieve a better model fit.

Table 2: Statistical Test of Initial First-order Measurement Model of Knowledge and Attitude

Statistical Test	Critical Value	Knowledge		Attitude	
		Topics (12 items)	Basic (6 items)	Pro-self (10 items)	Pro-social (7 items)
Chi-squares Test					
1.Chi-squared goodness of fit test	Chi-squared = non-significant	385.073	80.721	27.510	59.847
2.Normed chi-squared test	Ratio (Chi-squared/df) <= 3	7.131	8.969	1.376	4.275
Test Statistics Using Covariance Matrix					
1.Goodnes of fit index (GFI)	0.9<GFI<1	0.721	0.864	0.966	0.918
2.Adjusted goodness of fit index (AGFI)	0.9<AGFI<1	0.597	0.683	0.939	0.835
Comparisons with Independence Models					
1.Normed fit index (NFI)	0.9<NFI<1	0.709	0.873	0.951	0.923
2.Tucker-Lewis Index (TLI)	0.9<TLI<1	0.678	0.808	0.982	0.910
3.Comparative fit index (CFI)	0.9<CFI<1	0.736	0.885	0.987	0.940
Root mean square error of approximation (RMSEA) Root mean square error of approximation (RMSEA)	0<RMSEA<0.08	0.182	0.207	0.045	0.133
Result		**Rejected**	**Rejected**	**Accepted**	**Rejected**

Trimming process was carried out to improve the goodness of fit performances. Table 3 shows the statistical tests of modified first-order measurement model of knowledge and attitude. Subscale of topics, pro-self and pro-social showed a new measurement model with all values well fitted to an empirical data. However, for basic, AMOS 18 was unable to test any unobserved scales or subscales represented by less than three (3) variables. Hence, basic was reserved for final stage of structural models. Maximum likelihood (ML) estimation was used to estimate all model parameters simultaneously. Assessment on standardized residual covariance matrix showed that all residual covariances were less than 2.0 in absolute value, as well as, assessment of normality gives the values of skewness and kurtosis ranging between +1 and -1.

Table 3: Statistical Tests of Modified First-order Measurement Model Of Knowledge and Attitude

Statistical Test	Critical Value	Knowledge		Attitude	
		Topics (6items)	Basic (4 items)	Pro-self (10 items)	Pro-social (4 items)
Chi-squares Test 1.Chi-squared goodness of fit test 2.Normed chi-squared test	Chi-squared = non-significant Ratio (Chi-squared/df) <= 3	15.552 1.728	10.800 5.400*	27.510 1.376	2.114 1.057
Test Statistics Using Covariance Matrix 1.Goodnes of fit index (GFI) 2.Adjusted goodness of fit index (AGFI)	0.9<GFI<1 0.9<AGFI<1	0.972 0.936	0.864* 0.868*	0.966 0.939	0.994 0.972
Comparisons with Independence Models 1.Normed fit index (NFI) 2.Tucker-Lewis Index (TLI) 3.Comparative fit index (CFI)	0.9<NFI<1 0.9<TLI<1 0.9<CFI<1	0.964 0.974 0.984	0.967 0.917 0.972	0.951 0.982 0.987	0.994 0.999 1.000
Root mean square error of approximation (RMSEA) Root mean square error of approximation (RMSEA)	0<RMSEA<0.08	0.063	0.154*	0.045	0.017
Result		**Accepted**	***Rejected**	**Accepted**	**Accepted**

4.2.2.2 Confirmatory Factor Analysis of Second-order Measurement Model of Knowledg-Attitude

Table 4 shows the initial second-order measurement model of knowledge and attitude did not represent an empirical data accurately. Model modification or re-adjustment were required to obtain a better model that complied with suggested goodness of fit. After several inspections such as parameter estimates, regression weights, assessment of multivariate normal distribution and standardized residual covariances, all the problematic factors were removed from the initial model.

Table 4: Statistical Tests of Second-order Measurement Model Of Knowledge and Attitude (initial and modified)

Statistical Test	Critical Value	Knowledge		Attitude	
		Initial	Modified	Initial	Modified
Chi-squares Test 1.Chi-squared goodness of fit test 2.Normed chi-squared test	Chi-squared = non-significant Ratio (Chi-squared/df) <= 3	68.982 2.653	27.867 2.144	146.632 2.767	16.496 1.269
Test Statistics Using Covariance Matrix 1.Goodnes of fit index (GFI) 2.Adjusted goodness of fit index (AGFI)	0.9<GFI<1 0.9<AGFI<1	0.924 0.869	0.957 0.907	0.889 0.836	0.976 0.949
Comparisons with Independence Models 1.Normed fit index (NFI) 2.Tucker-Lewis Index (TLI) 3.Comparative fit index (CFI)	0.9<NFI<1 0.9<TLI<1 0.9<CFI<1	0.913 0.922 0.944	0.978 0.953 0.971	0.891 0.909 0.927	0.973 0.990 0.994
Root mean square error of approximation (RMSEA) Root mean square error of approximation (RMSEA)	0<RMSEA<0.08	0.094	0.078	0.097	0.038
Result		**Rejected**	**Accepted**	**Rejected**	**Accepted**

4.2.3 Structural Equation Model

Structural Equation Model (SEM), being the latest approach is capable to test empirical model simultaneously. It involves various statistical testing methods to explore the influence of knowledge on attitude. Figure 3 (in Appendix II) shows the graphical representation of a Structural Equation Model on knowledge-attitude. The two-step modeling approach suggested by Anderson and Gerbing (1988) was referred to. In the first step, a measurement model of knowledge and attitude (latent constructs) was developed and tested to correlate freely. In step two, a structural analysis was performed to test the relationships among latent variables. Using the same procedure as a measurement model, Table 5 shows the statistical test of the structural model. This initial structural result showed that the model had a good model fit.

Table 5: Statistical Tests of Structural Equation Model of Knowledge and Attitude

Statistical Test	Critical Value	Model
Chi-squares Test		
1.Chi-squared goodness of fit test	Chi-squared = non-significant	151.158
2.Normed chi-squared test	Ratio (Chi-squared/df) <= 3	1.497
Test Statistics Using Covariance Matrix		
1.Goodnes of fit index (GFI)	0.9<GFI<1	0.911
2.Adjusted goodness of fit index (AGFI)	0.9<AGFI<1	0.880 ~ 0.9
Comparisons with Independence Models		
1.Normed fit index (NFI)	0.9<NFI<1	0.906
2.Tucker-Lewis Index (TLI)	0.9<TLI<1	0.960
3.Comparative fit index (CFI)	0.9<CFI<1	0.966
Root mean square error of approximation (RMSEA)	0<RMSEA<0.08	0.052

However, assessment of the parameter estimates output in Table 6 revealed that the variance of e22 was -0.077. The value of variance cannot be negative and needed to be treated properly. Joreskog and Sorbom (1984) suggested that the model was erronous or the sample was too small. Therefore, this model was modified by combining both pro-self and pro-social into one scale of attitude.

Table 6: Variances of initial Structural Equation Model

	Estimate	S.E.	C.R.	P	Label
KNOWLEDGE	.151	.048	3.136	.002	par_14
e24	.420	.076	5.511	***	par_15
e20	.545	.095	5.746	***	par_16
e21	.330	.062	5.318	***	par_17
e22	-.077	.042	-1.814	.070	par_18
e23	.143	.062	2.291	.022	par_19
e2	.244	.039	6.201	***	par_20
e6	.137	.019	7.312	***	par_21
e7	.119	.019	6.360	***	par_22
e3	.338	.041	8.235	***	par_23
e4	.782	.085	9.190	***	par_24
e5	.261	.039	6.638	***	par_25
e16	.262	.042	6.205	***	par_26
e15	.332	.045	7.460	***	par_27
e14	.423	.052	8.145	***	par_28
e13	.433	.053	8.222	***	par_29
e11	.628	.072	8.764	***	par_30
e10	.766	.084	9.109	***	par_31
e8	.610	.068	8.996	***	par_32
e1	.352	.044	8.007	***	par_33
e18	.074	.016	4.556	***	par_34

	Estimate	S.E.	C.R.	P	Label
e12	.455	.056	8.132	***	par_35

Table 7 shows the results of statistical tests that complied successfully with an acceptable limit of goodness of fit. All the measured items had the skewness and kurtosis below 1.0 in absolute value. It indicated that the empirical data were normally distributed around the mean. Therefore, the sample data were considered to have good univariate normalities. After various attempts to fulfill the requirements of all benchmarked fit indices were carried out, this modified model was accepted as a final structural equation model of knowledge-attitude (Appendix I-Quesionnaire).

Table 7: A Modified Structural Equation Model of Knowledge-Attitude

Statistical Test	Critical Value	Model	Interpretation
Chi-squares Test 1.Chi-squared goodness of fit test 2.Normed chi-squared test	Chi-squared = non-significant Ratio (Chi-squared/df) <= 3	124.951 1.436	Good fit to the just-identified model.
Test Statistics Using Covariance Matrix 1.Goodnes of fit index (GFI) 2.Adjusted goodness of fit index (AGFI)	0.9<GFI<1 0.9<AGFI<1	0.920 0.890 ~ 0.9	Good fit to the just-identified model.
Comparisons with Independence Models 1.Normed fit index (NFI) 2.Tucker-Lewis Index (TLI) 3.Comparative fit index (CFI)	0.9<NFI<1 0.9<TLI<1 0.9<CFI<1	0.918 0.968 0.973	Percent improvement over null model
Root mean square error of approximation (RMSEA)	0<RMSEA<0.08	0.048	Good model fit

Figures 3(i) and (ii) in Appendix II show the results of assessing how much students' knowledge influence their attitude towards sustainability using the final structural model of knowledge-attitude, conducted on 188 first year engineering students at the beginning and end of first semester of 2011/2012 session. Students were exposed to different teaching and learning approaches such as lecturing, problem-based learning, poster presentation, sustainable project and competition. At the beginning of the semester, the highest factor loading was basic knowledge (0.62) followed by topics (0.42) and this knowledge influenced students' attitude at 0.37 of the factor loading. And at the end of the semester, the highest factor loading of basic knowledge increasing to 0.78 followed by topics (0.71) and attitudes (0.50). This results indicate that attitude could improve and develop through knowledge and learning experience. In term, these learning activities have also developed students soft skills, such as teamwork, creative thinking, problem solving, time management, lifelong learning and communications.

5. Discusssion

The use of structural equation model (SEM) has been successfully developed a model of o assess students' knowledge-attitude with a minimum number of parameters but still adequate to describe the observed covariance structure. The initial model of 36 items was reduced to 15 items. Measurement of knowledge which consists of two subscales, i.e, 1) topics related to sustainability issues with 5 items (on climate change, environmental pollution, global warming, ozone layer depletion and 3Rs), and 2) basic knowledge of sustainable development with 3 items (on definition of sustainable development, three elements of sustainability, and principles of sustainable development). The measurement of attitude consists of 7 items which combined both subscales of pro-self and pro-social into one scale. The minimum items in the questionnaire are easier for the respondent to answer. Most students felt bored and refused to answer a large number of questions and responded without reading each statement properly. Thus, these respondent's datas would affect the result of analysis, a good and simple instrument needs to be developed, evaluated and presented.

On the other hand, it is proven that the basic knowledge on sustainable development has a strong correlation to the students' attitudes. The model has also successfully measured the level of sustainable development among students, why they are required to understand sustainable development and how much it changed their attitude towards sustainability. Besides, this model can also be proposed as a tool for the lecturers to prepare their teaching material and what are the important elements of sustainable development they have to address. This model would help them to determine what level of knowledge and attitude towards sustainability before they undergo the course. At the end of the semester, they could evaluate how much students have learned and fulfilled the learning outcomes. As effective teachers, they must be professionally knowledgeable in sustainable development and capable to integrate it into their courses.

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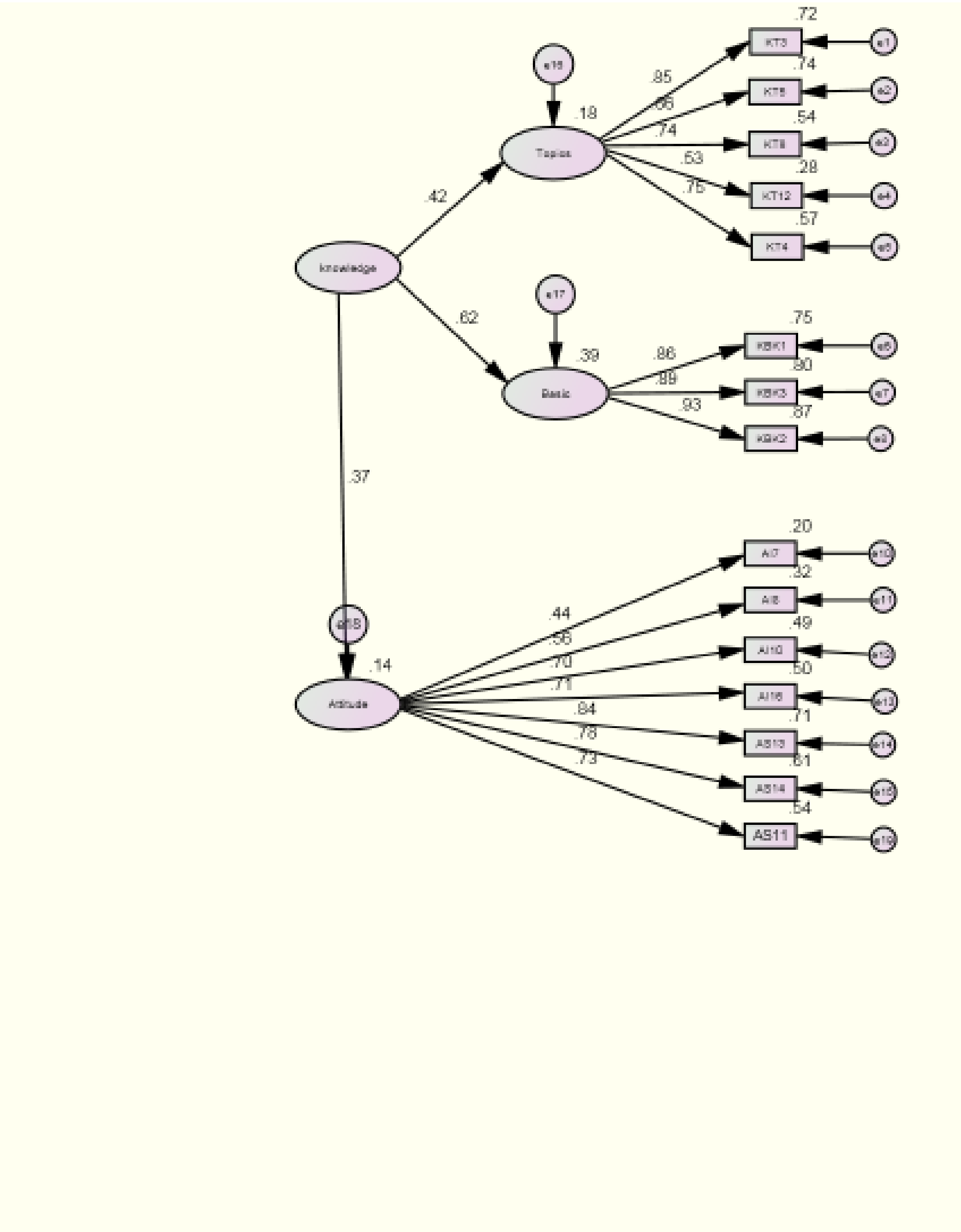
Appendix I

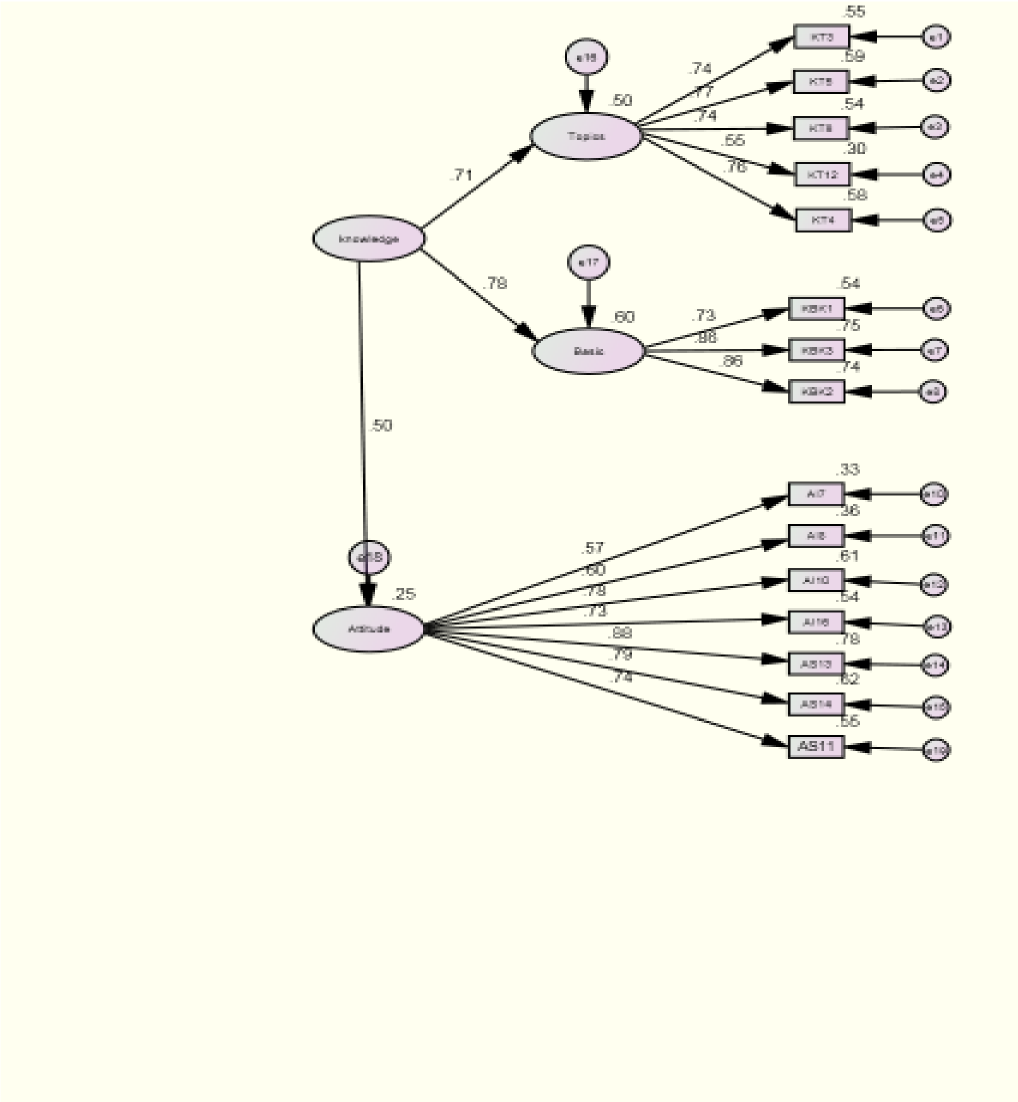
Questionnaire to Assess Students' Knowledge-Attitude Towards Sustainability

Knowledge	Topics	KT 3	Climate Change
		KT4	Environmental Problems
		KT5	Global Warming
		KT8	Ozone Layer depletion
		KT12	3Rs
	Basic Knowledge	KBK1	Definition of sustainable development
		KBK2	Three elements of sustainability
		KBK3	Principles of sustainable development
Attitude		AI7	I take a short shower in order to conserve water
		AI8	If I found water leaks, I would report it
		AI10	İ pick up litter when I see it in a park or a natural area
		AI16	I collect recycle items such as papers, bottles and glasses
		AS11	I volunteer to work with local charities
		AS13	I asked others what we can do to help reduce pollution
		AS14	I asked my parents not to buy products made from non-renewable resources

Appendix II



(i)Beginning of semester



(ii) End of Semester

Figure 3: A Structural Model of Knowledge-Attitude towards Sustainability