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Determining Significant Components of Pittsburgh Freshman Engineering Attitudes Scale Using Exploratory Factor Analysis among Engineering Students

[1]Tahira Anwar Lashari, [1]Maizam Alias, [2]Zainal Abidin Akasah and [3]Mohd Jahaya Kesot
[1]Faculty of Technical and Vocational Education,
[2]Faculty of Civil and Environmental Engineering,
[3]Department of Civil Engineering, Universiti Tun Hussein Onn Malaysia (UTHM),
Batu Pahat, Parit Raja, Malaysia

Abstract: Student's attitude towards the subject matter promotes continuing effort and persistent behaviour towards the programme. As possessing a positive attitude towards engineering education directs to increase in academic prosperity. However, prevalent practices in engineering education do not often consider the non-cognitive learning needs. Therefore, this study investigates to identify how an attitude towards engineering affects student's perception towards the subject matter. Standard tool the pittsburgh freshman engineering attitudes scale was adopted and employed. The study used quantitative survey design with a purposive sampling strategy. The sample consisted of 70 diploma civil engineering students (26 male and 44 female). The obtained data on factor analysis using SPSS revealed seven extracted factors with 35 measurable items. The highest factor 0.92 was found on item 46 whereas the factor 0.410 was found on item 41.

Key words: Attitude towards engineering education, factor analysis, diploma students, employed, non-cognitive

INTRODUCTION

There has been a growing interest among engineer educators towards non-cognitive/affective factors including attitude, empathy and communication skills and their association on student academic performance. The engineering students are not merely expected to have the ability to create and to be innovative rather they are also expected to have the ability to be empathetic, self-starters and to develop a positive attitude that reflects affective attributes such as individual values, perception, motives and interests (Alias *et al*., 2014). However, in engineering discipline much is given on achieving the cognitive goals of learning and the lower emphasis on affective learning as the engineering discipline is perceived as an object-oriented discipline rather than a people-oriented discipline. Therefore, the teaching and learning practices is designed according to the learning outcome. This unhealthy practice may hinders the development of the appropriate attributes in future engineers (Esa *et al*., 2015). Consequently, acknowledging the role of affective domain within the engineering education provides an engineering lecturer with the guidance to develop unique instructional materials that can attract positive attitude towards the subject matter and student's interest in promoting future learning. Thus, the internalization (affective learning) closes the gap between these processes (achieving cognitive goals) and help in promoting a clear understanding of the concepts at hand, resulting in individual learning output and unique reality.

Attitudes are composed of beliefs, opinions and thoughts linked up with behaviour and it influences the level of consistency. Sherman and Fazio (1983) note the importance of attitudes in learning by stating that "attitudes lead to the biased interpretation of ambiguous material as well as to selective attention to and learning of information". Attitude is not only associates with student performance although, linked to beliefs about their capacity to perform certain tasks. Attitude of students may contribute towards their academic performance. Research has supported the notion that positive attitude towards learning can be developed by means of optimistic feeling. A positive attitude leads students to the state of readiness for a specific learning material (Malik *et al*., 2010). Therefore, enhancing student's awareness of their potentials raised the insight belief which resulted in active engagement in a variety of learning activities. Hence, the more students put efforts in learning, the more they take responsibly of their actions. Consequently affective dimension of learning in engineering can be used to achieve cognitive learning goals.

Corresponding Author: Tahira Anwar Lashari, Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia (UTHM), Batu Pahat, Parit Raja, Malaysia

Tella *et al.* (2009) reported that students who tends to have a positive attitude towards learning expects success in academic performance and they are more internally motivated as compare to those students who have a negative attitude towards learning. Moreover, the learning process also takes place well in a classroom. A student attitude towards learning is triggered by the situation and attitude is also related to the prediction of one's response to an object. Understanding student's attitude towards engineering is vital in order to help students to keep sustain their interest towards engineering education. Therefore, having a clear explanation and a fair assessment would help the students to change their student's attitude gradually towards learning. It is important for educators to know student's attitudes toward the discipline they are teaching. In-addition, positive attitude towards a discipline is considered as a driving force behind coping with learning difficulties therefore, it should be taken care of by lecturer in order to get achieve learning goals (Ajzen and Fishbein, 1980).

Although, much of the efforts have been put forward to investigate the role of attitude on student's academic performance; however, there have been few attempts to authenticate whether possessing a positive attitude towards engineering education direct to increase in academic prosperity while considering Malaysia (Sarwar *et al.*, 2010; Esa *et al.*, 2015). Therefore, this study investigates to identify how an attitude towards engineering affects student's perception towards the subject matter which in-turned keeps promoting students continuing effort and persistent behaviour in the programme. Thus, factor analysis has been utilized to access the most relevant and significant measurable items.

Theory of Reasoned-Action (TRA): Theory of Reasoned-Action (TRA) was developed by Martin Fishbein and Icek Ajzen which posits that a person's individual behaviour is determined by behavioural intentions whereby behavioural intentions are a function of an individual's attitude toward the behaviour and subjective norms. Behavioural intension is the intension to exercise an actual behaviour. It is the function of both attitudes towards behaviour and subjective norms towards that particular behaviour. Attitudes are sum of beliefs about a particular behaviour. Subjective norms are personal norms that influence one's social environment based on behavioural intension and beliefs. Therefore, theory of reason action is based on triadic interconnected chain (Fig. 1) resulting in explicit behaviour through behavioural intension, attitudes and subjective norms (Mayer, 2008).

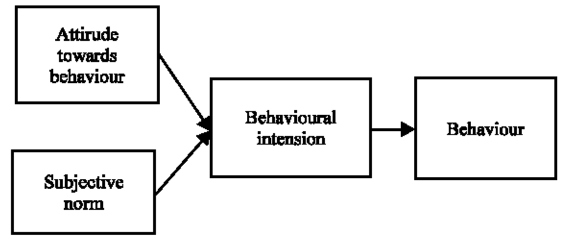

Fig. 1: Triadic interconnected chain on TRA (Ajzen and Fishbein, 2000)

Attitude towards engineering education: An attitude is a behaviour pattern, predisposition to specific adjustment or a conditioned response to social stimuli. Attitudes are developed in learning when curiosity is produced (Chowdhury, 2004). Attitude towards engineering education is defined as an opinion that can influence individual's behaviour towards engineering that can modify one's behaviour accordingly in a certain situation. Attitude is a mental state which reflects neural state of readiness. Attitude is a combination complexed beliefs, values, behaviours and motivation. Attitudes are systems or constructs that are composed of three interrelated qualities: affective responses, cognitions, behavioural intentions. They vary in direction (positive or negative), degree (amount of positive or negative feeling) and intensity (the level of commitment the individual has to the position). Thus, attitudes are studied to measure the tendency and the strength of attitude in predicting behaviour (Mian, 1998).

Literature claims that positive attitude towards a discipline influences students success in the course as positive attitude, positive thinking and optimism are known to be a core element of academic achievement (Felder *et al.*, 1988; Papanastasiou and Zembylas, 2004; Li, 2012). Consequently, it can be stated that the more positive attitude towards engineering, the more student tends to have a low level of anxiety have greater persistence in facing learning difficulties and have coping skills during the time of hardships in learning. Similarly, Kirchner has also revealed that students having a positive attitude towards engineering education tend to have a low level of depression, anxiety and they have greater resistance to learning difficulties and coping skills during the time of hardships in learning (Kirchner, 2012).

Once a positive attitude is developed towards a course, that positive attitude leads a student to accept challenges of learning and develops a confidence of carrying out the learning process and finding the solutions to a problem. Furthermore, students who have positive attitude towards engineering tend to perform better than the students who have negative attitude towards engineering. Attitudes are not only associates with student performance but also linked to beliefs about their capacity to perform certain tasks, i.e., self-efficacy. Therefore, the interpretation to certain events is influenced by beliefs and those predisposed beliefs determine performance on academic tasks and the challenges the tasks represent in professional training. Thus it is important for educators to know student's attitudes toward the discipline they are teaching. The operational definition of an attitude towards engineering is the scores obtained by the participants on the Pittsburg Freshman Engineering Attitudes Scale (PFEAS) scale. A high score reveals high positive attitude towards engineering while a low score reveals less positive attitude towards engineering, respectively.

MATERIALS AND METHODS

Research design: In this study, quantitative research design; questionnaire survey was used with a purposive sampling strategy as the method of primary data collection. Questionnaire surveys have been found to be the most common way of data collection for exploration (Trochim and Donnely, 2006). The study used purposive sampling strategy which is sample is selected on basis of special characteristics which in the study are "fresh" engineering students. Hence, the purposive sample in the study is the engineering students. A study was conducted in the Universiti Tun Hussein Onn Malaysia (UTHM). Trial out is so-called feasibility study was run prior to the main study. It underwent rigorous testing by the mean of different statistical procedures. A well-conducted trialing the instrument or trail run allows the researcher opportunities to administer the research questions in the same manner as in main study (Chenail, 2011).

Population and sample: In this study, the target population was diploma recipients from civil engineering program. A set of questionnaires using quantitative approach were given to students to fill the instruments namely the Pittsburg Freshmen Engineering Attitude Survey (PFEAS). The Pittsburg Freshmen Engineering Attitude Survey (PFEAS) was used to measure the changes in student attitudes over time towards engineering education. It was suggested by Li (2012) that the number of representative and adequate sample size for pilot study is 30. However, a large number of sample gives more valid and reliable results and thus it will be more representative. Therefore, the study took seventy students (44 girls and 26 boys) as a representative sample which was the cluster of a classroom. The purpose of the trialing the instrument was to see if they are able to understand the wording of the questionnaire as the questionnaire was in English language and the population to which those questionnaires were administrated was bilingual (Teijlingen *et al.*, 2001).

Instrument: The Pittsburg Freshman Engineering Attitudes Scale (PFEAS) was used to measure attitude of engineering students. The scale was developed by Besterfield-Sacre in 1999 at the University of Pittsburg. The scale is designed to evaluate student's perceived ability to cope with the challenges in engineering. In original tool of the Pittsburg Freshmen Engineering Attitude Surveys (PFEAS), there are fifty items rated on Likert scale from 1 (strongly disagree) to 5 (strongly agree), respectively. Fifty items were divided into thirteen clustered or sub-scale areas as listed earlier in Table 1. The sub-scales were also reaffirmed with the original scale division.

These sub-scales are the domain of the instrument's construct, i.e., freshman attitude about Engineering: General Impressions of Engineering (GIE); Financial Influences of studying engineering (FI); Perception of how Engineers Contributions to Society (PECS); Perceptions of work engineers do and the Engineering Profession (PEP); Enjoyment of Math and Science Courses (MSC); Engineering perceived as being and "Exact" Science (ES) and Family Influences to Studying Engineering (FISE), Confidence in Basic Engineering Knowledge and Skills (CBEKS); Confidence in Communication and Computer Skills (CCCS); Adequate study habits (ASH); Working in Groups (WIG); Problem Solving Abilities (PSA) and Engineering Capability (EC), respectively.

Table 1: The 13 clusters of original PFEAS tool

Items grouped in sub-scales	Attitude sub-scales	Definition of sub-scales
1, 2, 3, 4*, 5, 6*, 7, 8*, 9*	Career impressions	General Impression of Engineering (GIE)
10, 14, 21, 23	Jobs and salary	Financial Influences for studying engineering (FI)
11, 20	Society contribution	Perception how Engineers Contribute to Society (PECS)
12, 17, 18, 22, 25, 27, 28	Perception of work	Perception of work Engineers do and engineering Profession (PEP)
13, 19*	Math enjoyment	Enjoyment of Math and Science (MSC)
15, 26	Exact science	Engineering perceived as being an "Exact" Science (ES)
16*, 24*	Family influence	Family Influences to Studying Engineering (FISE)
29, 30, 31, 32, 35	Basic knowledge	Confidence in Basic Engineering Knowledge and Skills (CBEKS)
33, 34	Communication skills	Confidence in Communication and Computer Skills (CCCS)
39, 46	Study habits	Adequate Study Habits (ASH)
37, 41, 43, 45	Group work	Working in Groups (WIG)
38, 40, 42, 49, 50	Problem solving ability	Problem Solving Abilities (PSA)
36, 44, 47, 48	Engineering ability	Engineering Capability (EC)

*Items are reversed coded (Malik *et al.*, 2010)

Data analysis procedures and ethical consideration: The analysis of the data has been carried out by using Statistical Packages of Social Sciences (SPSS) Version 20. Factor analysis a statistical procedure were used to analyzed data. The selection of the procedures was based on the applicability of the data as well as on the research objectives. Certain ethical consideration were taken into account prior giving the pilot study and these ethical consideration were written permission from the original authors, debriefing and informed consent from the participants.

Written permission via email was given by the original author for the instrument to modify/use the original version of the instrument. Official permission and informed consent was sought to draw a sample from Universiti Tun Hussein Onn Malaysia (UTHM). As soon as official permission was obtained, the approval letter was sent to the lecturer (who was willing to do research) in diploma level in civil engineering program to ask permission to conduct the study.

During the data collection procedure, a brief description on the study was given at the beginning of the study (debriefing) (Jones, 2007). A briefing on the purpose of the study was given to the participant prior to the tools distribution by the lecturer who was also a member of the research team to provide motivation for respondent to give accurate responses to the questionnaires. The questionnaire was administrated directly and individually. All the participants cooperated with the researcher by giving their responses on the questionnaire. They complete the measures within a single class period. At the end the students were thanked and highly appreciated for the voluntary participation. The students were further encouraged to participate in such activities. Additionally, inform consent was given to each of the participant of the study.

The informed consent clearly stated that participants are voluntarily participated and their information will be kept strictly confidential. Participants were given information regarding the pros and cons of the study. All the records and participants identities were treated as confidential as required by ethics which were suggested by Jones (2007).

RESULTS AND DISCUSSION

Factor analysis: Factor analysis is widely used statistical technique for detecting the most relevant latent variable in the observed measures and allows the researcher to analyze individual scores (Field, 2005). It is statistical technique with a purpose of reducing a set of observed variables in terms of a small number of latent factors. Factor analysis lessens the large dataset into smaller subset of measurement items which means factor determines the values of the observed variables. It explore the reasons of why certain variables or identified factors are correlated. Moreover, factor analysis it is a statistical procedure of removing the redundancy or duplication from a set of correlated variables. The factor analysis performs a dual task namely identification of underlying factors and screening of variables. Identification of underlying factors means it clusters the variables into homogeneous sets and allows researcher to gain a more insights into the categories. Screening of variables means it identifies the grouping to select the most relevant which represents the concept.

Factor analysis is frequently used to developed questionnaire. There are basically two types of factor analysis namely Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). This paper has utilized exploratory factor analysis to identify the underlying factors. The current study adapted standard instruments. Therefore, the initial inspection of factor analysis was analyzed to determine sample adequacy via Kaiser-Meyer-Olkin (KMO) measure of sample adequacy and the correlation matrix was analysed by means of determinant value. The necessary sample size for the factor analysis resulting in many “rules-of-thumb” and one of the rules-of-thumb is determining the number of items in a variable. Researchers should have “at least 10-15 subjects per variable” as suggested by Field (2000). Attitude variable was measured using PFEAS tool. Seven factors are determined with 35 items. In reviewing the result of initial factor analysis indicated that sample size was adequate which is above the accepted value 0.5 as suggested by Field (2005); Jones (2007). Kaiser-Meyer-Olkin (KMO) is a basic assumption that should be met for the factor analysis to be used. KMO is a statistical test which determines the sample adequacy which means it measure how suited the data is for factor analysis. The value in KMO statistics varies between the ranges from 0-1. The accepting value in is >0.5. The value ranges from 0.5-0.6 are considered as moderate. The values ranges from 0.6-0.7 are considered as good whereas the value above 0.7 falls in the range of being superb (Field, 2005). In this study, the obtained value in KMO measure is 0.7 which falls in the range of good thus indicating adequate sample size based on the previous research evidence. Table 2 gives depiction on the KMO coefficient obtained on the pilot study data.

Table 2: The kaiser-mayer-olkin measure estimation

KMO and Bartlett’s test	Values
Kaiser-Meyer-Olkin	0.707
Measure of sampling adequacy	
Approx χ^2	1918.958
Bartlett’s test of sphericity	
df	1225.000
Sig.	0.000

Table 3: The initial rotated components/factors matrix of adopted PFEAS

	Factor							
Veriables	1	2	3	4	5	6	7	Remarks
ATT25	0.833							
ATT28	0.742							
ATT12	0.720							
ATT26	0.714							
ATT17	0.660							
ATT11	0.653							
ATT1	0.652							
ATT9	-0641							
ATT3	0628							
ATT18	0524							
ATT27	0495							
ATT43	0.430							
ATT20								Rejected due to factor loadings is <0.4
ATT10								Rejected due to factor loadings is <0.4
ATT22								Rejected due to factor loadings is <0.4
ATT46		0.929						
ATT47		0.820						
ATT45		0.755						
ATT13		0.654						
ATT42								Rejected due to factor loadings is <0.4
ATT50								Rejected due to factor loadings is <0.4
ATT48			0.695					
ATT44			0.664					
ATT24			0.501					
ATT41			0.410					
ATT3								Rejected due to factor loadings is <0.4
ATT5				0.725				
ATT7				0.648				
ATT34				0.591				
ATT35				0.467				
ATT29				0.438				
ATT6								Rejected due to factor loadings is <0.4
ATT4								Rejected due to factor loadings is <0.4
ATT15								Rejected due to factor loadings is <0.4
ATT40								Rejected due to factor loadings is <0.4
ATT23					0.736			

Table 4: The initial rotated components/factors matrix of adopted PFEAS

	Factor							
Veriables	1	2	3	4	5	6	7	Remarks
ATT21					0.622			
ATT31					0.421			
ATT39								Rejected due to factor loadings is <0.4
ATT49								Rejected due to factor loadings is <0.4
ATT30						0.618		
ATT36						-0.617		
ATT16					0.485	0.507		Rejected due to cross loadings
ATT2						0.487		
ATT32						0.432		
ATT37								Rejected due to factor loadings is <0.4
ATT38							0.577	
ATT8							0.546	
ATT14					0.447		-0.454	Rejected due to cross loadings
ATT19							0.408	

Extraction method: Principal axis factoring; rotation method: promax with Kaiser normalization

The scale was adopted and factor analysis a statistical test was applied to determine the significant measurable items and relevant factor in the scale. Factor analysis extracted seven factors with 35 measureable items on a 5-point Likert type ordinal rating scale. Two variables (i.e., 14 and 16) were dropped because of the cross-loading on the other component. About 12 observed variables were found to load on the first factor. About 5 observed variables were found on the 4th factor. About 4 observed variables were found on the 2nd, 3rd and 6th factor while 3 observed variables were found on the 5th factor, respectively. Items 4, 6, 10, 14, 15, 16, 20, 22, 33, 37, 39, 40, 42, 49 and 50 were discarded as the factor loaded were <0.4 as suggested by Field (2005) (Table 3 and 4). In-addition, the reason for not considering the rejected items to be measured based on the requirement of the research.

Item 25 "engineers are creative "measures engineering student's perception towards their potential and ability. The other measures to assess attitude towards engineering are also aligned with the components measuring engineering ability: For instance, the item 46 such as "I am good at calculus" measures engineering student's confidence towards basic engineering knowledge and skills. In addition items such as item 10 "engineers are well paid"; item 49 "I am good at speaking" and item 50 "I am good at computer skills "are rejected. The reason for not considering them to be measured based on the requirement of the research as the study aims to measure the attitude of students towards the subject. Moreover, these items were measuring general perception towards communication and computer skills. This means the extracted items via factor analysis has found to be significant and relevant to the study. Therefore, these measurable items could be used to elicit worthy and insight information regarding engineering attitude towards the discipline. Thus, these extracted items are found to be significant as measure perception of engineer's students who most likely chose engineering majors and completed degree requirements were those who held positive perceptions toward engineering and had a measurable interest in science and technology.

CONCLUSION

The study set out to determine the most relevant items from an attitude scale. The Pittsburg Freshmen Engineering Attitude Survey (PFEAS) scale was adopted and then factor analysis a statistical technique has been performed on adopted scale which was used to measure the changes in student attitudes over time towards engineering education. The original tool was consisted of 50 items; however, factor analysis extracted seven factors with 35 measureable items on a 5-point Likert type ordinal rating scale. About 15 items were discarded either due to cross loadings and factor loading as the value was <0.4. Therefore, the pool of thirty-five items will be used for the main study to measure attitude of engineering students. The obtained result helps to select the most appropriate items from attitude scale. The highest and lowest factor lies between the range of 0.92 and 0.410. The highest factor items measured student's basic engineering knowledge and skills whereas the lowest factor measured student engineering compability. Consequently, it can be stated that adopted attitude scale measures appropriate and relevant attitude of engineering students towards the subject. Since, the current study took sample from the diploma civil engineering students; therefore, the future studies could considered the sample from other engineering disciplines.

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