

# REVIEW OF MEASUREMENT ITEM OF ENGINEERING STUDENTS' LEARNING ENVIRONMENT: CONFIRMATORY FACTOR ANALYSIS

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## ABSTRACT

*This survey study was carried out to review the measurement items of learning environment model for engineering students. A total of 535 respondents were involved in this research. The variables presented in this research were the peer interaction, lecturer interaction and education facilities. Data were analyzed descriptively for reliability (Cronbach Alpha values) and confirmatory factor analysis (CFA) was used to obtain 3 factor solutions using AMOS software. The results showed that the Cronbach Alpha was on the classification of high and very high which was higher than 0.70. Result of CFA confirmed 3 factors solution with data collected was fit with model. The study also proposed a model of learning environment for engineering students.*

***Keywords;*** *peer interaction, lecturer interaction, education facilities, confirmatory factor analysis*

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## 1 INTRODUCTION

Globalization has created a greater human capital needs of knowledge workers (k-workers) at the professional and semi-professional level (Fazlinda et al., 2013). Human capital development is an effort to achieve cost savings and improve the performance of the industry (Seri Bunian et al., 2012). Employers prefer to employ knowledge workers (k-workers) as it helps to move their industry in line with the economic growth of a country (Fazlinda et al., 2013). Therefore, Technical and vocational education and training (TVET) play an important role for socio-economic development of a country to meet the challenges of global skilled labour (k-workers) market (Ansari & Wu, 2013). Malaysia Ministry of Education (MOE) has aggressively embarked on a mission to develop students with soft skills program in order to produce high quality human capital, knowledgeable, competitive, has the creative and innovative features and move in line with industry requirements and social needs of the country (Siti Nor Habibah et al., 2012).

As such, learning environment in education institution seem to be a crucial factors in order to produce human capital with high competency to meet the challenges of global skilled labour (k-workers) market. The learning environments were seen as the quality of teaching and learning context in which the learning process occurs. The studies of learning environments are still relevant until today and its important is undebateable in improving students' learning outcomes especially for TVET learning environment (Saemah et al., 2012). As such, it is advisable for TVET system has it own specific learning environment instrument in order measure to what extend our learning environment contributed in producing high quality human capital. Previous studies has shown that learning environment contributed to high learning outcome and that so this study aimed to modify and validate existing questionnaire using confirmatory factor analysis to measure engineering student's (TVET) learning environment.

Theme in the study of learning environments came from Murray's (1938) work on the difference between outside observations and the perceptions of those directly involved within the specific environment being studied. Then, vast studied been done which leads to analysis of data from a variety of viewpoints and levels of statistical analysis, including the class mean or the individual student score. Before that, the concept of the learning environment has been started by Lewin and Murray who examine the learning environment on human behaviour. According to Lewin (1936), environmental and individual are determinants of human behavior. Lewin's ideas were developed by Murray (1938) using the Model of Needs-Pressure to clarify the relationship between individuals (I) and environment (E). Murray concluded that human behaviour is influenced by individual needs and environmental demands.

The field of learning environments has started with the work of Herbert Walberg and Rudolf Moos and their individual attempts at studying participants' perceptions of various learning situations (Moos, 1974). Based on his research into a variety of human environments, Moos (1974) developed a scheme for classifying human environments into relationship, personal development and system maintenance and change dimensions. These dimensions enable various components of an environment to be classified and sorted. Relationship dimension assessed the nature and relationships, the level of involvement,

support and assistance given by individuals in their psychosocial environment. Personal developmental dimension assessed individual progress towards the self-enhancement such as examination, the grade given and awards received. The third dimension, maintenance and change of a system, assessed the extent to which the environment is regulated, clarity of the classroom rules controlled, objective and goals of study.

Fraser (1998) defines the learning environment as social, psychological, and pedagogical contexts in which learning occurs and which can affect student achievement and attitudes. The learning environment was seen by the researcher (Ramsden, 1991; Biggs, 1999) as the quality of teaching and learning in which the context occurs. According to Ramsden, students will appreciate the environment in which educators are always trying to help them to learn. In summary, the study of learning environments was initiated by Walberg at the end of the 1960s and developed by Fraser in the early 1980's. The studies of learning environments are still relevant until today because of its importance in helping to improve learning outcomes.

The field of classroom learning environments has developed as shown in the large number of research, literature reviews and books regarding this field (Taylor & Fraser, 2013). The international attention that this area has received (Fisher and Khine, 2006; Fraser, 1998; Fraser, 2007; Fraser, 2012; Taylor & Fraser, 2013; Goh & Khine, 2002) helped to inform the worldwide of the importance of this area of research. It also led to many questionnaires being developed for this field of research. The learning environment research has involved the development and validation of some widely-used questionnaires, such as the Course Experiences Questionnaire (Ramsden, 1991), (McInnis et al., 2001), Classroom Environment Scale CES (Moos, 1979), My Class Inventory (Fraser & Fisher, 1982), Questionnaire on Teacher Interaction (QTI, Wubbels and Levy, 1993), Science Laboratory Environment Inventory (SLEI, Fraser et al., 1995), Constructivist Learning Environment Survey (CLES, Taylor et al., 1997) and What Is Happening In this Class? (WIHIC) (Fraser et al., 1996).

A great deal of research in education field has been heavily dependent on measures of academic achievement and other learning outcomes; however, these measures cannot provide a complete description of the educational process (Pickett & Fraser, 2010). Over the past 40 years, significant progress has been made in the research of the learning environments of classrooms and schools (Moos, 1994; Moos, 1974; Walberg & Anderson 1968; Fisher and Khine 2006; Fraser, 1998; Fraser, 2007; Fraser, 2012; Taylor & Fraser, 2013; Goh & Khine 2002). Previous research has enabled educators to develop a more in depth understanding of how students learn and their learning environment that can affect the teaching and learning process. Hence, a convincing evidence has been provided by previous research that the quality of the learning environment in educational institutions is a significant determinant of student learning (Fraser, 2007). Studies on the learning environment that evolved from 1960 has produced many instruments by researchers who studied this field.

During the past 20 years, vast research has been conducted involving the development and validation of instruments to assess the psychosocial dimensions of learning environment (Dorman, 2003). It also stated that few studies have reported the use of confirmatory factor analysis (CFA) to support the structural characteristics of the instruments. Given the increased use of CFA within a structural equation modelling

framework, it is timely that CFA be employed to validate learning environment instruments (Dorman, 2003). Therefore, this study focused on determining the appropriate instrument based on the learning environment needs for Malaysia technical student using CFA that not been methodically explore yet as mentioned by Dorman (2003) that the use of valid instruments is central to the conduct of meaningful research.

Table 1 showed three construct of the learning environment been studied by previous researchers. Construction of these three constructs was based on the analysis of model and previous studies. Learning environment factors studied by previous researcher were lecturer interaction (Kember & Kam, 2000; Ramsden et al., 2007; Cabrera et al., 2001; Karagiannopoulou & Christodoulides, 2005; Seri Bunian et al., 2011), learning resources (Smith & Bath, 2006; McInnis et al., 2001; Seri Bunian et al., 2011) and learning community (Smith & Bath, 2006; McInnis et al., 2001; Seri Bunian et al., 2011) as a sub construct. Meanwhile, Ruhizan et al. (2012) and Kamaruddin (2010) conducted a study on college community student regarding the relationship between learning environment and employability skills. Learning environment constructs been studied were peer interaction, lecturer interaction, contextual learning, co-curriculum and education infrastructure.

**Table 1. Learning environment factors researched by previous researchers**

No.	Factor	Researchers
1.	Peer Interaction	Smith & Bath (2006); Kamaruddin (2010); Norlia (2006); Fraser (1998); Pascarella (1985), Seri Bunian et al. (2011); Mohd Yusof et al. (2013)
2.	Educational Facilities	Smith & Bath (2006); Kamaruddin (2010); Norlia (2006), Seri Bunian et al. (2011)
3	Lecturer Interaction	Ramsden (1979, 1991); Biggs (1999); Kember & Leung (2005); Seri Bunian et al. (2011); Mohd Yusof et al. (2013)

Moreover, constructs used for this study must also meet the scheme of Moos (1974), which categorizes people's environment into three dimensions of relationship, personal development, system maintenance and change as shown in Table 2. Therefore, these three constructs were selected for this study based on the frequent used among researcher, the most crucial element of learning environment and its meet Moos Scheme.

**Table 2. Learning environment factors based on the Moss Scheme**

No.	Factors	Description	Moos Scheme
1.	Peer Interaction	To which extent the role peers influence the learning.	Relationship
2	Lecturer Interaction	Related to the quality of the teaching lecturer.	System Maintenance and Change
3	Educational facilities	To which extent the learning resources are provided for the students.	Relationship Personal Development

## 2 METHODOLOGY

The sample consists of randomly selected students based on systematic sampling by Krejcie and Morgan (1970), which has a population of 10501 students and the number of sample size is 373. A total of 600 questionnaires were distributed to students in their final semester and a total of 535 questionnaires are usable. Samples were adequate based on the recommendations of Hair, Anderson, Tathan, and Black (2006), in utilizing the CFA technique, the number of samples must exceed 500 if the number of constructs is more than six, some of constructs measured has less than three items and the communalities are low.

Researchers are also suggested to increase the number of samples if they encounter any of these conditions (1) data displays abnormal characteristics, (2) using alternative estimation procedure, and (3) anticipating more than 10% of missing data. The participants were 535 final semester diploma students from eight technical institutions in the country. All participants belonged to the same cohort and were all enrolled in engineering programme. They were selected randomly to complete the questionnaires and the measures were administered during regular class sessions coordinated with help from lecturers. Students were briefed on the nature of the questionnaires and confidentiality was confirmed. They were allowed as much time as they needed to complete the questionnaires, typically requiring 25 to 35 minutes.

The questionnaire was designed using three construct measuring learning environment namely peer interaction, lecturer interaction and educational facilities. With these three constructs, researchers produce a combination of a questionnaire to measure learning environment adapted from previous studies (Kamaruddin, 2010; Norlia, 2006; Seri Bunian et al., 2011). The adapted designed questionnaires were referred to a specialist in the field and have been modified accordingly.

Reliability test (Cronbach Alpha), principal component factor analysis and Confirmatory factor analysis (CFA) was performed to determine the validity and confirmatory of constructs. Cronbach Alpha coefficient was used to assess internal consistency of each scale. A principal component factor analysis was used in pilot study of this study. Factor analysis has been usually known as a statistical technique for data reduction. However, it was also useful in searching for structure among a set of variables. Particularly, the principal component factor analysis provided direct insight into the interrelationships among variables and empirical support for addressing conceptual issues relating to the underlying structure of the data (Hair et al., 1998).

Further, Confirmatory Factor Analysis (CFA) was conducted on the measurement model based on hypotheses factors used by Analysis Moment of Structure - AMOS version 18. Next to strengthen the position of the hypothesized constructs, construct validity is done. Construct validity involves the validity of the convergent validity and discriminant validity. Convergent Validity were evaluated based on the coefficient of each item loaded significantly ( $p < 0.05$ ) and composite reliability of a latent variables (Anderson & Gerbing, 1988; Fornell & Larcker, 1981).

The value of composite reliability more than 0.70 indicate convergent validity is in a good position (Fornell & Larcker, 1981; Hair et al., 2006). Meanwhile, discriminant validity was evaluated by average variance extracted for all 10 constructs which must be less than 0.9. If the value is less than 0.9 constructs, then discriminant validity is achieved (Hair et al., 2006). All the items examining the learning environments of respondents were based on Likert Scale as shown in Table 3.

**Table 3. Description of Likert Scale**

Description
1: Strongly Disagree
2: Disagree
3: Partially Disagree
4: Agree
5: Strongly Agree

### 3 FINDING

The quality of the instrument under evaluation will be discussed with respect to its reliability and validity using appropriate statistical techniques.

#### 3.1 Reliability of Instrument

The reliability of the items for the learning environment in Cronbach Alpha value that measures internal consistency of the variables is shown in Table 4. According to Babbie (1992), Cronbach Alpha values are classified based on the classification in which the reliability index of 0.90-1.00 is very high, 0.70-0.89 is high, 0.30-0.69 is moderate, and 0.00 to 0.30 is low. The results showed that the Cronbach Alpha for this instrument is on the classification of high and very high, higher than 0.70. According to Sekaran (2003), Cronbach Alpha value must be greater than 0.5. While Mohd Najid (1999), suggests a minimum value equal to 0.6. We can conclude that this instrument has high reliability since Cronbach Alpha value for all variables is more than 0.5 (Table 4).

**Table 4. Value of Cronbach Alpha for Learning Approach**

Variable	Number of Items	Number of Items Excluded	Cronbach Alpha Value
Educational facilities	13	-	0.90
Peer Interaction	8	-	0.86
Lecturer Interaction	8	-	0.89

#### 3.2 Principal Component Factor Analysis (PCA)

A pilot study of 252 sample was done prior to real data collection. This step was done according to Hair et al. (2006) in order to confirm that all three constructs being studied was valid using principal component factor analysis (PCA) with the varimax rotation. Results showed in Table 5, indicated that 3 factor solutions with Eigen values above 1.0. The value of Kaiser-Meyer-Olkin Measure of Sampling Adequacy  $0.899 > 0.6$  is adequate for inter-correlation while Barlett Test was significant (Chi Square = 1958.030,  $p < 0.05$ ). The anti-image correlation matrix by The Measure of Sampling Adequacy (MSA) is more than the value of 0.5. Items IR3, IR4, IP1, IP2, KPR1, KPR1, KPR1, KPR1, KPR2, KPR3, KPR4, KPR5, KPR6 and KPR12 dropped based on the criteria by Hair et al (2006), where each item should exceed the value of 0.50. Total variance explained for this loading was 60.12%. This value is sufficient as according to Sekaran (2003) the total variance explained must be more than 50 %.

**Table 5. Factor Analysis**

Items	Peer Interaction	Lecturer Interaction	Educational facilities	Extraction (Cumanalities)
IR1	.775			.626
IR2	.752			.613
IR5	.772			.639
IR6	.617			.468
IR7	.768			.677
IR8	.700			.573
IP3		.693		.612
IP4		.730		.571
IP5		.705		.614
IP6		.735		.688
IP7		.763		.634
IP8		.750		.624
KPR7			.744	.583
KPR8			.683	.532
KPR9			.759	.625
KPR10			.759	.614
KPR11			.766	.649
KPR13			.640	.481
Total variances explained				60.12%

### 3.3 Confirmation Factor Analysis (CFA)

Further, confirmation factor analysis (CFA) was performed to examine the underlying relationship among the set of indicators. This analysis sought support for the three learning environment factors (LE) and ten employability skills components (ES). Maximum likelihood estimation was used to generate an estimated full-fledged measurement model. Maximum likelihood was selected because it is a robust estimation method capable of handling large samples and distributions that depart from normality (Arbuckle, 1997). The measurement model consists of the indicators for each construct. All latent constructs (LE and ES) are permitted to correlate with each other. Model fit was evaluated using the fit

indices. Individual parameter estimates were tested using critical ratios.

Assessment of model fit was based on multiple criteria including both absolute misfit and relative fit indices. The absolute misfit indices included the root mean square error of approximation (RMSEA; Hair et al. 2006) and the relative goodness-of-fit indices used in the study were the comparative fit index, Tucker Lewis index and incremental-fit-index (CFI, TLI, IFI; Hair et al., 2006). Arbuckle (1997); Arbuckle and Wothke (1999) states that a model is fit when the index shows that (i) the value of CMIN/df is between 1 and 5, considered acceptable or acceptable fit between model and data, (ii) indices of CFI and TLI approach 1.00, and (iii) the RMSEA index of 0.08 or less indicates a reasonable error and can be accepted.

The assessment of fit (overall fit) for the LE model in table 6 shows that it fits and can be accepted based on the indicators suggested by Hair, Anderson, Tathan & Black, (2006). The value of degrees of freedom index, CMIN/df = 3.151, CFI = 0.934, TLI = 0.924, IFI = 0.934, and RMSEA = 0.063, indicate that data from the sample fit the learning environment (LE) model. Figure 1 shows measurement model for Learning Environment.

**Table 6. Fit Indices for the Measurement Model**

<i>Fit Index</i>	<b>Hypothesized model (n=525)</b>	<b>Recommended values</b>	<b>Source</b>
$\chi^2/df$	3.151	$\leq 5.00$	Hair et al (2006)
CFI	0.934	$\geq 0.90$	Bagozzi & Yi (1988); Hair et al (2006)
RMSEA	0.063	$\leq 0.08$	Browne & Cudeck (1993); Hair et al (2006)
TLI	0.924	$\geq 0.90$	Bagozzi & Yi (1988); Hair et al (2006)
IFI	0.934	$\geq 0.90$	Bagozzi & Yi (1988); Hair et al (2006)

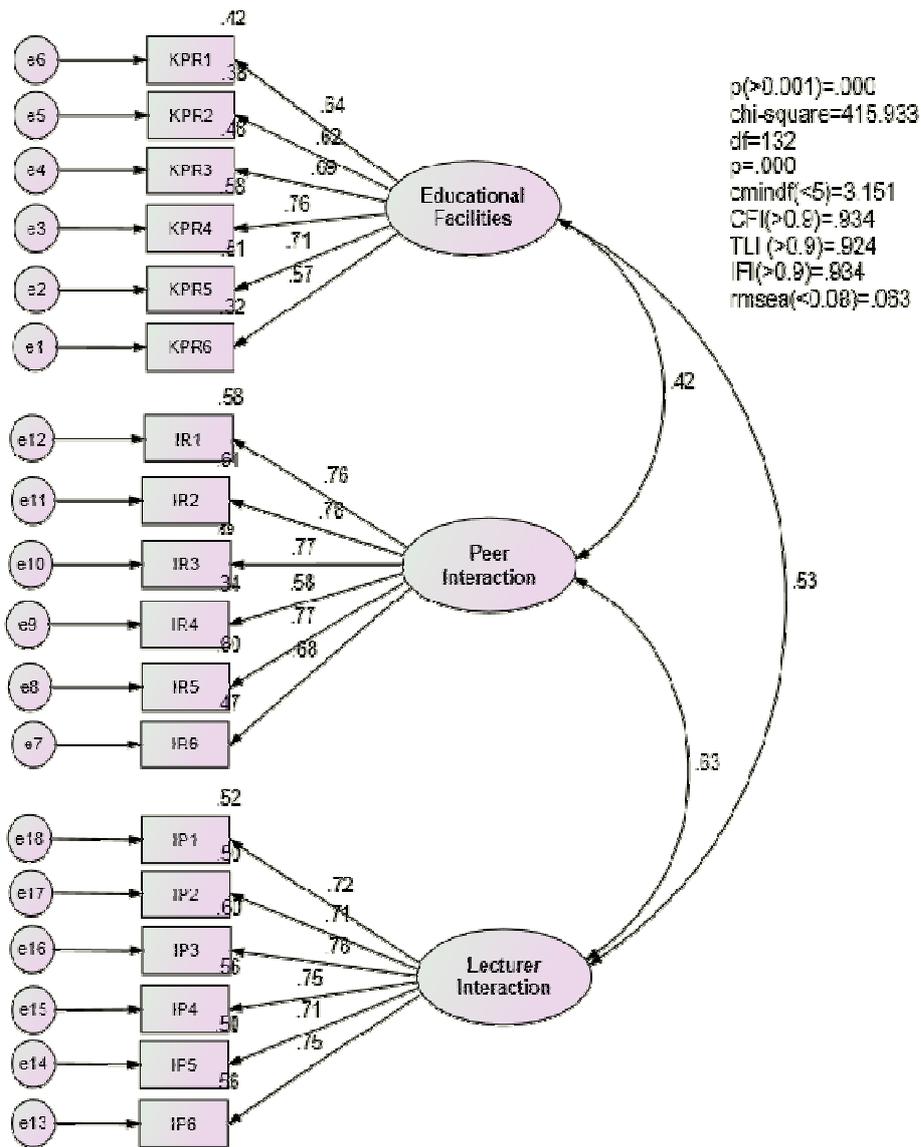


Figure 1. Measurement Model for LE

Convergent validity (Table 7) was also evaluated based on the coefficients of each item, the reliability of the constructs and the average variance extracted for a latent variable (Fornell & Larcker, 1981; Anderson & Gerbing, 1988). The analysis showed that the lowest construct's reliability value was greater than 0.70 and that the average variance extracted range between 0.45 to 0.54. Discriminant validity was evaluated by comparing the squared correlations between the two constructs and the average variance extracted. If the average variance extracted less than 0.9, discriminant validity is achieved (Hair et al., 2006). Table 8 shows discriminant validity was less than 0.9. Hence, the results of this analysis show that convergent validity and discriminant validity were achieved.

**Table 7. CFA results (standardized loading, composite reliability and average variance extracted)**

Construct	Item	Convergent validity		
		Factor loading	Composite reliability <sup>a</sup>	Average variance extracted <sup>b</sup>
Educational facilities	KPR1	0.645	0.83	0.45
	KPR2	0.616		
	KPR3	0.691		
	KPR4	0.761		
	KPR5	0.715		
	KPR6	0.568		
Peer Interaction	IR1	0.760	0.87	0.53
	IR2	0.781		
	IR3	0.766		
	IR4	0.582		
	IR5	0.773		
	IR6	0.684		
Lecturer Interaction	IP1	0.719	0.88	0.54
	IP2	0.709		
	IP3	0.776		
	IP4	0.751		
	IP5	0.707		
	IP6	0.749		

Note:

<sup>a</sup> Composite reliability =  $(\sum \text{loading factor})^2 / \{(\sum \text{factor loading})^2 + (\sum \text{indicator error measurement})\}$

<sup>b</sup> Average variance extracted =  $\sum (\text{loading factor}^2) / (\text{number of item})$

**Table 8. Discriminant validity of constructs**

Construct	(1)	(2)	(3)
(1) Educational facilities	0.90		
(2) Peer Interaction	0.42	0.90	
(3) Lecturer Interaction	0.53	0.63	0.90

Note: Diagonal representing average variance extracted less than 0.9

## 4 CONCLUSION

The results showed that the Cronbach Alpha value classification is high and very high, which was more than 0.70. This instrument has high reliability in accordance with the classification of Babbie (1992), while the factor analysis indicated three factors which peer interaction, lecturer interaction and education facilities. Each item shows a satisfactory loading of more than 0.5 (Hair et al., 2006). Meanwhile, CFA was performed shows that the assessment of model fit was based on multiple criteria including both absolute misfit and relative fit indices. The assessment of fit (overall fit) for the model shows that it fits and can be accepted based on the indicators suggested by Hair et al. (2006) which indicate that data from the sample fit the learning environment (LE) model. The results of convergent validity and discriminant validity of this analysis also achieved and fulfil the requirement of multivariate analysis. Thus, the questionnaire developed was suitable to be used to study the learning environment involving mainly these three factors. The most crucial focus is this instrument was also suitable to be used in the context of education in Malaysia. However, further study is required for different sample or much bigger sample to further validate the validity of the instrument.

Hence this study provides preliminary evidence of the validity of the instrument. The findings are expected to contribute to the preparation of teachers, educators and instructors of TVET program in schools and higher education. The findings can also be used to inform the relevant agencies in establishing national standards of learning environment for TVET in Malaysia. The information obtained can provide guidance for TVET system to equip themselves with positive learning environment to facilitate the delivery of knowledge to TVET students that will prepare students to pursue a career in the relevant industry after graduating. The use of the appropriate instrument will support lecturer and students in preparing for the ever changing demands of the industry. Soft skills such as human relations skills, communication skills, ethical behaviour skills and cognitive skills are the attributes that being considered by employers when reviewing job applicants (Hamid, 2009). Therefore by using the instrument, predictor that contributed to these skills can be determined and manipulated to achieve positive outcomes.

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