AN EMPIRICAL STUDY ON ENGINEERING FACULTY PERCEPTIONS TOWARDS eLearning-PEDAGOGY AND AN ANALYSIS USING STRUCTURAL EQUATION MODELING (SEM) APPROACH

R. Parthiban
Dr. S. Dhanapal

Abstract

This research article analyses the Engineering Faculty perceptions with regard to various pedagogical elements for course design and additional features for video based eLearning components. The empirical data were collected from 150 teachers from twelve Engineering Institutions (10 Engineering Colleges and 02 Deemed to be Universities) located in seven districts of Tamilnadu, India. The Data analysis was carried out to ascertain the relationship between the variables using Structural Equation Modeling (SEM). The analysis showed that absolute fit indices fit the empirical data, thus establishing that the proposed model has the acceptable fit.

Keywords: *Engineering Institutions, Faculty, eLearning, Pedagogy, Structural Equation Model (SEM)*

Introduction

The opinion of the Engineering Faculty about various pedagogical elements for course design and additional features for video based eLearning components were elicited through a survey instrument. Data were collected from 150 teachers from different category of profile, background, and institutions from seven districts of Tamilnadu comprising of Kanchipuram, Tiruvallur, Madurai, Sivagangai, Virudhunagar, Tirunelveli and Kanyaumari of Tamilnadu, India.

To estimate the factors, Confirmatory Factor Analysis (CFA) was carried out and to develop an appropriate model for eLearning-Pedagogy, Structural Equation Modeling (SEM) technique was used. All the measures used in proposed model satisfy the recommended values of Fit-Statistics.

Need for the Study

In India, engineering / technology education forms the fourth largest group in terms of enrollment in the higher education.

Natarajan R., (2002) [1] describes the current Engineering Education scenario as "Quantitative expansion in technical education without simultaneous quality assurance". **RamaRao P., (2012)** [2] has pointed out that for an annual student intake greater than 15, 00,000, there is a faculty shortage of about 80,000 (for a faculty: student ratio of 1: 15). Of these, about 60,000 persons are needed with a Ph.D. and about 25,000 more are needed with a Master's degree.

The shortage of qualified teachers is so serious that a multi-pronged solution is required. Since the bulk of teachers employed in these engineering institutions are a product of the same system, quality remains a vicious circle for these institutions.

Subbarao (2013) [3] calls for a more imaginative use of ICT to make good lecture and courseware widely available to the technical education system, to offset the effects of shortage of quality faculty and suggests that eLearning resources available in India and abroad as the obvious candidates to improve the quality and pedagogy of engineering education in India.

Supplementary eLearning resources as a Solution

Definition of eLearning

The Joint Information Systems Committee **JISC, (2004)** [4] of UK Higher education defines eLearning as: 'Learning facilitated and supported through the use of information and communications technology (ICT)'. The eLearning includes; delivery of courses, on-line assessment, student to student and student to teacher communications, use of Internet resources, and other learning activities involving ICT and the Internet. The ***British Standard 8426:2003*** [5] defines e-learning as any learning that uses ICT.

eLearning resources in India and Abroad

The National Mission on Education through Information and Communication Technology (NME-ICT) project is an initiative of the Ministry of Human Resource Development, Government of India, which aims at providing a wide range of educational services to higher education particularly engineering education. NME-ICT products include NPTEL, Virtual Labs, Spoken Tutorial, e-Yantra, A-VIEW, and Talk to Teacher. In International arena MIT-OCW, Khan Academy, Stanford Engineering Everywhere, Harvard Resource Materials, OLI & OER initiatives and recently MOOCs are available eLearning resources for the learners.

Need for developing an eLearning-Pedagogy

King (2008) [6] recommends that courses for modern Engineering Curriculum shall be based on *sound pedagogy*, embrace concepts of inclusivity and be adaptable to new technologies and inter-disciplinary areas and also discusses the use of remote access laboratories; project centred curricula and improved assessment method.

Therefore the design of the supplementary eLearning resource has to include a wide variety of learning experiences for meeting the needs of students of varying academic achievement, aptitude and socio-economic background.

Hence it is required to arrive at 'Pedagogy for eLearning' of engineering content suitable for the present generation of students of Engineering in the country. This study attempts to determine from the perceptions of teachers of Engineering Institutions towards the various pedagogical elements for course design and additional features for video based eLearning components required for effective learning leading to the development of an appropriate eLearning-pedagogy.

Significance of the Study

This study attempts to identify the various required pedagogical elements for course design and additional features for video based eLearning components for Supplementary eLearning resources. This study also analyses the relevance of these components for an Effective Curriculum and Academic Performance of the Learners.

Objectives of the Study

The study had the following four objectives

1) To determine the various desired features of the pedagogical elements for course design towards effective learning

2) To determine the additional features for video based eLearning components for Supplementary eLearning resources towards effective learning

3) To develop an eLearning-Pedagogy for Self-learning and teaching

4) To evaluate whether all the measures fit the recommended value, indicating a good fit of the Structural Model for the collected data

Research Methodology

This research study employs Descriptive Design, using Survey method. The present study uses cross sectional survey of sample with teachers of Engineering Institutions. The data is collected from 150 teachers (***Male:*** *55,* ***Female:*** *95*) from 12 Engineering Institutions *(10 Engineering Colleges and 02 Deemed to be Universities)* of Tamilnadu using Purposive Sampling method. All the 150 teachers teach B.E (Computer Science and Engineering), B.Tech (Information Technology) and Master of Computer Applications programmes.

Descriptive Survey Research is amenable for generalization. In this study Descriptive Survey Research is used for development of an eLearning-Pedagogy using Statistical Modeling (SEM).

Instruments Developed for Data Collection

A Survey questionnaire was developed for response by teachers which comprised of items about various pedagogical elements for course design and additional features for video based eLearning components. Responses are registered with items constructed on Likert's scale. Researcher used 4-point scale for many of the items using closed-ended questions. The neutral option of the respondent is avoided due to the ambiguity in the response as it does not tell anything about the respondent's level of the attribute / attitude towards the questions. The administration of the research instrument's responses was administered directly by the researcher.

Statistical Techniques Used

Structural Equation Modeling (SEM*)* is a methodology for representing, estimating, and testing a network of relationships between variables (measured variables and latent constructs) **Diana Suhr, (2006) [7].**

SEM compares a model to empirical data leading to fit-statistics assessing the matching of model and data **(Nachtigall, 2003) [8]**. If the fit is acceptable, the assumed relationships between latent and observed variables (measurement models) as well as the assumed dependencies between the various latent variables (structural model) are regarded as being supported by the data.

In order to recognize a right model for the sample data, fit indices have no single statistical test of significance (**Schumaker and Lomax, 1996**) **[9]**.

There are number of goodness of fit (GOF) indices with which to make comparisons, thus "fit should be evaluated from the standpoint of numerous fit statistics" (**Campbell et al., 1995:6**) **[10]**. The overall fit measures, the goodness-of-fit statistic (GFI), adjusted goodness-of-fit statistic (AGFI), and root mean squared residual (RMR), are all useful measures in assessing the quality of the hypothesized measurement model. Absolute fit indices determine how well a priori model fits the sample data (**McDonald and Ho, 2002**) **[11]**.

The analysis using SEM for the present study consists of the relationship between the latent variables of Course Design and Additional Features and their corresponding observed variables which are listed in **Table 1.**

Table 1: Latent Variables and Observed Variables used in SEM

Si. No.	Latent Variables	Observed Variables
01.	**Course Design-CD (05)**	Matching Curriculum (**MC**), Concept Based Learning (**CBL**), Co-Operative Learning (**COL**), Inclusion of Feedback (**IF**), Established Learning Model (**ELM**)

02.	**Additional Features-AF (08)**	Audio Transcript (**AT**), Navigation (**NG**), Printed Materials (**PM**), Work Book (**WB**), Localisation of Examples (**LOE**), Video Animation (**VA**), Simulation (**SN**), Discussion Forum (**DF**)
03.	**CD, AF**	Benefits in Curriculum (**BC**), Learners Performances (**LF**)

Sample Size determination for Structural Equation Model (SEM)

The sample size needed for Structural Equation Model were established by the following attributes,

• **Rachna and Susan (2006)** [12], recommended the smallest sample sizes for Path Analysis (n = 18), Confirmatory Factor Analysis (n = 63), and Stuctural Equation Model (n = 52). In this study data is collected from 150 teacher respondents. The sample size of 150 satisfies the **Rachna and Susan** specified criteria**.**

• **Nachtigall et. al., (2003)** [13]**,** established the minimum sample size being a subject parameter-ratio of 10:1. The total number of parameters used in the teacher Questionnaire was 15, comprising of 13 Observed variables and 02 Latent variables.
Applying the **Nachtigall** ratio of 10:1, the required sample size is 150.

• Using **Hoetler (1983)** [14] Fit-Statistics, the minimum sample size determined for the current model is 53.

The sampled population of the current study consisted of 150 teachers from Engineering Institutions (***Male:*** *55*, ***Female:*** *95*).

Data collection and sample

Out of the total 210 questionnaires distributed, researcher was able to collect only 150 questionnaires fully completed in all aspects which amount to 71% of response rate.

Structural Equation Modeling for the development of an eLearning-Pedagogy

The variables used in the Structural Equation Model are

I. **Observed / Endogenous variables:** Matching Curriculum (**MC**), Concept Based Learning (**CBL**), Co-Operative Learning (**COL**), Inclusion of Feedback (**IF**), Established Learning Model (**ELM**), Audio Transcript (**AT**), Navigation (**NG**), Printed Materials (**PM**), Work Book (**WB**), Localisation of Examples (**LOE**), Video Animation (**VA**), Simulation (**SN**), Discussion Forum (**DF**), Benefits in Curriculum (**BC**) and Learners Performance (**LP**)

II. **Unobserved / Exogenous variables:**: Course Design (**CD**) and Additional Features (**AF**)

While applying Likert-types scales in research, it is necessary to calculate the Cronbach's alpha coefficient for reliability and consistency (**Joseph et al., 2003**) [15].

The Cronbach's Alpha Reliability, Mean and Standard Deviation of the dimensions are shown in the **Table 2**.

Table 2: Result of Cronbach's Alpha Reliability analysis for the Dimensions

Dimensions	Cronbach's Alpha	Mean	Standard Deviation	Number of items	Number of Respondents
CD	**0.852**	29.35	5.674	10	**150**
AF	**0.923**	68.60	11.571	20	
BC and LP	**0.897**	20.71	4.446	07	

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Structural Equation Modeling for eLearning-Pedagogy

Interpretation of the CFA Measurement Model Part-I

Model Parameter Estimates for CFA for the latent variable CD and its components are shown in the **Table 3**.

Table 3: Model Parameter Estimates for 05 factors on CD

Variables			UnStandardised co-efficient	Standardised co-efficient	t value	P value
CD	<---	MC	1.731	0.217	7.961	<0.001**
	<---	CBL	1.550	0.163	9.508	<0.001**
	<---	COL	0.572	0.079	7.236	<0.001**
	<---	IF	0.647	0.080	8.107	<0.001**
	<---	ELM	0.613	0.085	7.213	<0.001**

Note: ** denotes significant at 1% level

The outcome of the Confirmatory Factor Analysis for the latent variable Course Design and its components is given in **Figure 1.1**.

Figure – 1: CFA – Measurement Model Part-I (error terms not shown on diagrams)

The analysis suggests that all five factors contribute significantly to Faculty perceptions on Course Design.

The influence of the factors on CD as to be interpreted as follows,

The co-efficient of the factor **Matching of Curriculum** is 1.731 which represents the partial effect of *Course Design* towards *Matching of Curriculum*, holding *Concept Based Learning*, *Co-operative Learning*, Inclusion *of Feedback* and *Established Learning Models* as constant. The estimated positive sign implies that such effect is positive that *Matching of Curriculum* would increase by 1.731 for every unit increase of *Course Design* and this coefficient value is significant at 1% level.

Similar interpretations have been made for the other 4 factors [Concept Based Learning, Co-operative Learning, Inclusion of Feedback and Established Learning Models].

Interpretation of the CFA Measurement Model Part-II

Model Parameter Estimates for CFA for the latent variable CD and its components are shown in the **Table 4**.

Table 4: Model Parameter Estimates for 08 factors on AF

Variables			UnStandardised co-efficient	Standardised co-efficient	t value	P value
AF	<---	AT	1.387	0.222	6.248	<0.001**
	<---	NG	0.582	0.074	7.826	<0.001**
	<---	PM	3.717	0.300	12.402	<0.001**
	<---	WB	1.493	0.174	8.562	<0.001**
	<---	LOE	0.543	0.076	7.139	<0.001**
	<---	VA	1.074	0.125	8.607	<0.001**
	<---	SN	0.576	0.072	7.998	<0.001**
	<---	DF	0.564	0.068	8.278	<0.001**

Note: ** denotes significant at 1% level

The outcome of the Confirmatory Factor Analysis for the latent variable AF and its components is given in **Figure 2**.

Figure – 2: CFA – Measurement Model Part-II (error terms not shown on diagrams)

The analysis suggests that all eight factors contribute significantly to Faculty perceptions on AF.

The estimated positive sign implies that such effect is Positive and an increase in every component will result in corresponding increase in AF.

The interpretation of the Structural Model for eLearning-Pedagogy

Interpretation of CD and AF on Learners Performance

Model Parameter Estimates for Structural Model using the latent variable CD and AF for Benefits in Curriculum (BC) are shown in the **Table 1.5**.

Table 5: Model Parameter Estimates for CD and AF on BC

Variables			UnStandardised co-efficient	Standardised co-efficient	t value	P value
BC	<---	C D	0.496	0.175	2.838	0.005*
	<---	AF	0.642	0.171	3.748	<0.001**

Note: ** denotes significant at 1% level, * denotes significant at 5% level

Model Parameter Estimates for Structural Model using the latent variable CD and AF for learners Performance (LP) are shown in the **Table 6**.

Table 6: Model Parameter Estimates for BC on LP

Variables			UnStandardised co-efficient	Standardised co-efficient	t value	P value
LP	<---	BC	1.183	0.210	5.647	<0.001**

Note: ** denotes significant at 1% level

The effect of latent variables CD and AF (with all their components as described earlier) on benefits of curriculum is given in **Figure 3**.

Figure –3: eLearning-Pedagogy Model using SEM (error terms not shown on diagrams)

The positive coefficients of 0.50 and 0.64 respectively indicate the positive correlation of CD and AF with benefits of curriculum.

The estimated positive sign implies that such effect is Positive and an increase in CD or AF will result in corresponding increase in Benefits of Curriculum.

Interpretation of Benefits of Curriculum on Learners Performance

The effect of benefits of curriculum on learner performance is also included in the Structural Model.

The positive coefficients of 1.18 and indicates the positive correlation of Benefits of Curriculum on Learners Performance.

STRUCTURAL EQUATION MODELING (SEM) MODEL-FIT ASSESSMENT

Structural equation modeling was used to analyze the suitability of the model based upon the collected samples. **Anderson and Gerbing (1988)** [16], recommends that the reliability and validity of the survey instrument to be analyzed first, followed by the analysis of the Structural Model by using AMOS version 16. The structural equation model (SEM) is most useful when assessing the causal relationship between variables as well as verifying the compatibility of the model used (**Peter, 2011**) [17].

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Variables	Value	Suggested values
Chi-square value	**103.258**	**P-value >0.05**
P value	**0.127**	**≤ 5.00 (Hair et al., 1998) [18]**
GFI (Goodness of Fit Index)	**0.907**	**>0.90 (Hair et al. 2006) [19]**
AGFI (Adjusted Goodness of Fit Index)	**0.937**	**> 0.90 (Daire et al., 2008) [20]**
CFI (Comparative Fit Index)	**0.925**	**>0.90 (Hu and Bentler, 1999) [21]**
RMR (Root Mean Square Residuals)	**0.091**	**<0.14 (Tabachnik and Fidell, 2007) [22]**
RMSEA (Root Mean Square Error of Approximation)	**0.023**	**< 0.08 (Hair et al., 2006) [19,1]**

The statistically fit model was derived using Structural Equation Modeling, the Fit-Statistics is shown in **Table 7**.

Table 7: Model Fit -Statistics

Model Fit Summary

The P value of 0.127 is greater than 0.05 which indicates perfect fit.

The GFI (Goodness of Fit Index) is a measure of the proportion of variance and covariance that the proposed model is able to explain. . A value greater 0.95 indicates a good fit.GFI should exceed 0.90 for a good model. For a saturated model it will be an exact 1 GFI indicates the proportion of the variance in the sample variance-covariance matrix accounted for by the model. AGFI (adjusted GFI) is an alternate GFI index which is adjusted for the number of parameters. A value of 0.90 or more indicates a good fit.

The GFI value is 0.907 and AGFI value is 0.937. The GFI and AGFI values are is greater than 0.9 which represent it is a good fit.

CFI (Comparative Fit Index) evaluates the fit of the estimated model compared to the model where no relationship exists between the variables. Values greater than 0.95 are considered to be representative of a good fitting model.

RMR (Root Mean Square Residuals) is an index of the amount by which the variance and co- variances estimated by the model differ from the observed variances and co-variances. A small value indicates a good fit.

RMSEA (Root Mean Square Error of Approximation) indicates lack of fit compared to the saturated model. A value of 0.05 or less indicates good fit, and 0.08 or less indicates adequate fit.

The calculated CFI value is 0.925 which means that it is a perfect fit and also it is found that RMR value is 0.091 and RMSEA value is 0.023 which is less than 0.10 which indicated the model is good fit.

Epilogue

All the four objectives of the research study have been fully accomplished. As an outcome of the study a statistically valid and appropriate eLearning-Pedagogy Model has been developed through Structural Equation Modeling approach out of the perceptions of teachers from Engineering Institutions.

Conclusions

The model for eLearning-Pedagogy developed through the Structural Equation Modeling approach provides a guideline for the development of eLearning resources as a supplement to the teaching-learning process in Engineering Institutions.

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About the Authors:

First Author:
Shri. R. Pathiban, Full-Time Research Scholar, Curriculum Development Centre, National Institute of Technical Teachers Training and Research (Under Ministry of HRD, Govt. of India), Taramani, Chennai-600113. Tamilnadu. India. Email id: 84.parthi@gmail.com, Contact No: (Office) +91-44-22545442, +91-9962540094(Personal)

Second Author:
Dr.S. Dhanapal, Professor & Head of the Department [Research Supervisor], Curriculum Development Centre, National Institute of Technical Teachers Training and Research (Under Ministry of HRD, Govt. of India), Taramani, Chennai-600113. Tamilnadu. India. Email id: rasdp53@gmail.com, Contact No: (Office) +91-44-22545441