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Assessing the Relationship between Program Education Objectives and Program Learning Outcomes in Outcome-Based Education Using Partial Least Squares-Structural Equation Model

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Abstract**:** ***Institution of higher learning in Malaysia has implemented an Outcome-Based Education (OBE) since 2007. Among the crucial components of OBE were the Program Education Objectives (PEOs) and Program Learning Outcomes (PLOs). The development of PEOs has to take into consideration the involvement of stakeholders, in order to address their needs and requirements and also must in line with the institutional vision and mission. PLOs, on the other hand, has to be aligned with PEOs to attain OBE. The study withal strive the relationship between PLOs and PEOs in OBE by using Partial Least Squares-Structural Equation Model (PLS-SEM) approach as the sample size was too small to utilize Structural Equation Modelling-Analysis of Moment Structure (SEM-AMOS). A simple random sampling was used to select 90 teachers throughout Malaysia. The selected teachers were a graduate of Sultan Idris Education University's (UPSI) Mathematics Education Degree (BEd Maths). From the analysis, it revealed that all the relationships in the developed model were significant at p<0.001. The results indicated that the developed model was strengthened by empirical analysis and in parallel with the preceding findings and theoretical framework. Apart of PEOs and PLOs path model, the study also successfully validated all the indicator variables depicted in PEOs and PLOs measurement model. This study had successfully developed and evaluated PEOs and PLOs relationship in OBE by means of structural equation model through PLS-SEM approach. In conclusions, the relationship between PEOs and PLOs can not only be expressed qualitatively, but also be modeled in the structural equation.***

Index Terms**:** ***Outcome-Based Education (OBE), Program Education Objectives (PEOs), Program Learning Outcome (PLOs), Partial Least Squares-Structural Equation Model (PLS-SEM).***

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I. INTRODUCTION

In preparing Malaysian youth to thrive in this complex and ever-changing future, Malaysia has experienced rapid changes in the educational system. In 2013, Malaysia's Ministry of Education developed Malaysia's Education Blueprint 2015–2025 (Higher Education), which aims to make Malaysia a high-income nation [1]. Higher education plays a significant role in sustainable magnification in this context. Edification for sustainable development initiatives usually seeks to provide learners with a more holistic understanding of the globe and anticipate the implications of sundry actions. Traditional higher education, fixates on responding to the demands of employers, industry and the rialto [2]. The implementation of OBE is therefore one of the major concerns in becoming a high-income nation. OBE incorporates the principles of mastery learning, but goes beyond them to address what students should learn and why. According to [3] OBE indicates the desirable results or skills that should be demonstrated by learners upon completion of an educational program. Ultimately, the quality of a program is evaluated by the ability of its graduates to fulfill their expected roles and duties in society. As stated by [4] the OBE approach in education involves the defining of educational objectives what graduates are expected to attain within a few years of graduation, what the graduates would be able to do at the time of graduation. OBE also involves identifying stakeholders and their involvement in the articulation and evaluation of educational objectives and outcomes, designing curricula that will produce the desired objectives and outcomes, mapping curricula how they contribute to educational objectives and outcomes, and developing the continuous improvement of educational processes for assessing and evaluation. It is expected that each student participating in the study program will attain the PEOs and PLOs. PEOs describe the skills and knowledge that students should have acquired upon completion of the program. These relate to the competencies, understanding, and behavior acquired through the program by the learners. Courses are then created to assist students in achieving the PLOs, with CLOs for individual courses that ultimately support the PLOs [5]. PLOs are the central organizational feature of student learning.

PLOs can be achieved and demonstrated through component courses, the CLOs and their evaluation are integrally linked to the PEOs. Many studies discuss on mapping and linkages between PLOs and PEOs in qualitative perspectives, see [6],[7],[8] and [9]. A little focus on the quantitative aspects of PLOs and PEOs. This study withal strive on the relationship between PLOs and PEOs in the form of a structural equation model (SEM) of the two latent variables in the quantitative forms by utilizing PLS-SEM.

II. PURPOSE OF THE STUDY

In establishing the relationship between PLOs and PEOs in the form of SEM, the study examines the relevant literature on OBE, PEOs and PLOs. As stated by [10], [11], [12], the PLOs and PEOs are linked in the sense that the development of PLOs must take into consideration of PEOs and OBE. [13] revealed that Course Learning Outcomes (CLOs), PLOs and PEOs are an interrelated learning outcomes of curriculum design. While [14] stated that the effectiveness of OBE implementation depends on a strong interconnection between the proper teaching, learning and assessment activities and the constructive mapping of the outcomes in terms of graduate attributes. Hence, the purport of this study is to develop and evaluate a structural model that illustrate the relationship between PEOs and PLOs.

III. METHODOLOGY

The study population consists of graduate teachers with the 2010-2015 BEd Maths program from Sultan Idris Education University. The population has been scattered all over Malaysia. A simple random sampling was used in the selection of these teachers. In this study, 90 teachers were selected as a sample. The teachers were asked to evaluate the importance of statements from PEOs and PLOs in achieving the OBE based on a 5-level Likert scale. The instruments were distributed by email in the form of questionnaire on the evaluation of PEOs and PLOs. The response instruments were received back by the researcher through email. In analyzing the data, SmartPLS 3.0 software was used.

A. The Establishment of PEOs and PLOs for UPSI's BEd Maths

The establishment of PEOs and PLOs for UPSI's BEd Maths program was based on the principles of OBE as stated by [15]. According to [15] "Outcome-Based Education means clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences. This means starting with a clear picture of what is important for students to be able to do, then organizing the curriculum, instruction, and assessment to make sure this learning ultimately happens". PEOs, on the other hand, are broad statements describing what graduates are expected to procure within a few years of graduation. The consequentiality of a degree PEOs stems from the authenticity that they represent the accomplishments that learners will achieve after graduation. PEOs are then the ultimate judgement of a degree program's consequentiality and achievement. In additament, PEOs have a direct connection with PLOs and a degree program curriculum. Curriculum and PLOs are preparing learners for PEOs. Consequently, if learners do not consummate the PEOs designated for the program after graduation, this shows that there are likely quandaries with a degree program's curriculum and PLOs. Curriculum developers must proximately consider PEOs and ascertain that the curriculum and PLOs prepare learners for the achievement of PEOs [3]. In developing the BEd Maths program of UPSI, members of the advisory board initiated the definition and a review of the program's PEOs and PLOs was discussed and approved at the faculty level. The program's aims and objectives were developed in line and to support the university's vision and mission. The program establishment process was carried out taking into account the needs of the program stakeholders (students, parents and industries) and the requirements of the Malaysian Qualification Agency (MQA). The advisory board members can also withal seek comments and feedback on the PEOs of the program. Additionally, students provide their feedback on PEOs through their advisory board members as well as through a special meeting with them. The advisory board meetings customarily had an open debate period during which PEOs-related were discussed in particular. The debate, however, was not limited to PEOs, but expands to curriculum and PLOs. Any vicissitude in PEOs could conspicuously affect PLOs and curriculum. The accreditation commission (MQA) will study the effect of these modifications and will establish a list of modifications related to PLOs and curriculum.

All the attributes/items in PEOs and PLOs were referred to BEd Maths program established by the department of mathematics, Faculty of Science and Mathematics, Sultan Idris Education University, Malaysia. The establishment of PEOs and PLOs of this program was in accordance with the procedure set by [3]. The BEd Maths PEOs were established based on three domains; cognitive (knowledge), affective (behavior and soft skills) and psychomotor (skills). While the PLOs were developed in accordance to eight criteria listed by [16]; that were knowledge, skill, community engagement, information communication technology, problem solving, leadership and lifelong learning and entrepreneurship. The graduate attributes that relate to PEOs and PLOs of BEd Maths program are displayed in Table 1 and 2.

Table 1. Program Education Objectives (PEOs)

Program Education Objectives (PEOs)	Graduate Attributes
PEO1	Gain knowledge and professional skills in mathematics that can fulfill the field of education.
PEO2	Be able to handle and manage teaching and learning process in lower and upper secondary school, pre-university and diploma level.
PEO3	Possess the knowledge and skills to conduct and manage research when pursuing higher education.
PEO4	Be able to conduct community and social work.

Table 2. Program Learning Outcomes (PLOs)

Program Learning Outcomes (PLOs)	Graduate Attributes
PLO1	Master the knowledge and pedagogy in the field of Mathematics.
PLO2	Master the technical and teaching skills in mathematics.
PLO3	Apply the educational technology and ICT.
PLO4	Embrace the professionalism, values, attitude and ethical behavior.
PLO5	Engage in community and social work.
PLO6	Communicate effectively and work in team.
PLO7	Manage information effectively and participate in lifelong learning.
PLO8	Creative and critical thinking.
PLO9	Engage in research.
PLO10	Response to the current issues in the field of mathematics.

B. PEOs and PLOs Evaluation Instruments

The development of PEOs and PLOs evaluation instruments was based on the PEOs and PLOs graduate attributes statement as listed in Table 1 and 2 without any modification as to maintain the originality of the statements established by the advisory boards and faculty committee members.

C. A Procedure in Applying PLS-SEM for PEOs and PLOs model in OBE

The development of PEOs and PLOs model in OBE through PLS-SEM followed a procedure as suggested by [17] including (i) identifying the structural model; (ii) designating the measurement model; (iii) data collection; (iv) path model estimation; (v) assessing PLS-SEM results of the measurement model; (vi) assessing PLS-SEM results of the structural model; and (v) interpretation of the results.

IV. FINDINGS AND DISCUSSIONS

A. The PEOs and PLOs Measurement and Structural Model

The research model comprises the measurement and structural model. There were two measurement models in this study that describe the relationship between latent variables and indicator variables. The latent variables shown in Fig. 1 were PROGRAM EDUCATION OUTCOMES (PEOs) and PROGRAM LEARNING OUTCOMES (PLOs) with their indicator variables (PEO1-PEO4) and (PLO1-PLO10) respectively. While the structural model was the path diagram that connected PLOs and PEOs in terms of relationship as shown in Fig. 1.

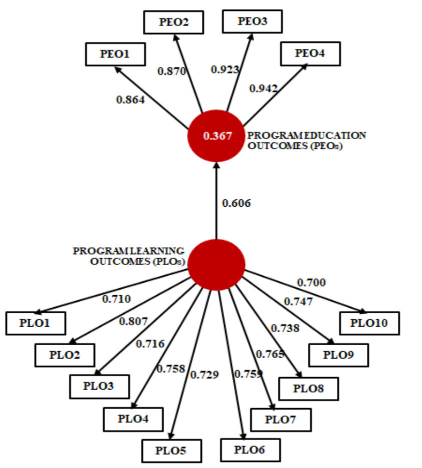

Fig. 1. PLS-SEM PEOs and PLOs Relationship Model

B. Assessing the Reliability and Validity of the Measurement Model

This section addressed the reliability and validity of the constructs as well as the estimation of the measurement model for each structure. Referring to [17], the measurement model evaluation is based on four criteria: (i) internal consistency based on the values of Alpha Cronbach (α) and Composite Reliability (CR); (ii) reliability of each indicator variables based on outer loading value; (iii) convergence validity based on the value of Average Variance Extracted (AVE); and (iv) discriminant validity based on cross loading of indicator variables, Fornell-Larcker criterion and Heterotrait-Monotrait (HTMT) ratio.

The PLS-SEM output as shown in Table 3 revealed that the Alpha Cronbach (α) value and CR for PEOs and PLOs constructs exceeded 0.70. As suggested by [18], the indicator variables in each construct are sufficient to measure the respective constructs. The reliability value for each indicator variables were also evaluated based outer loading value. Table 3 shows that all the outer loading for indicators variables were greater than 0.70. As suggested by [18] the outer loading values of greater than 0.70 are sufficient to represent the constructs. Meanwhile, the AVE values for the convergence validity of PEOs and PLOs shown in Table 3 exceeded 0.50. [19] suggested that the value of AVE value of greater than 0.50 indicates the validity of each construct is achieved.

Table 3. Outer Loading, Indicator Reliability, Cronbach Alpha, Composite Reliability and Average Variance Extracted Value

Construct	Item	Outer loading	Indicator reliability	α	CR	AVE
Program Education Objectives	PEO1	0.864	0.746	0.910	0.925	0.553
	PE02	0.870	0.757			
	PEO3	0.923	0.852			
	PEO4	0.942	0.887			
Program Learning Outcomes	PLO1	0.710	0.504	0.922	0.945	0.810
	PLO2	0.807	0.651			
	PLO3	0.716	0.513			
	PLO4	0.758	0.575			
	PLO5	0.729	0.531			
	PLO6	0.759	0.576			
	PLO7	0.765	0.585			
	PLO8	0.738	0.545			
	PLO9	0.747	0.558			
	PLO10	0.700	0.490			

The discriminating validity of the indicator variables based on cross loading is shown in Table 3. The discriminant validity value shows the extent to which the items used to measure a construct differ from the other constructs. The indicator's outer loading on the associated construct were greater than all of its loadings on other constructs (i.e the cross loading). This indicates that PEOs is distinct from PLOs by empirical standards. The research also revealed that the value of the AVE square root for each construct was greater than the value of the corresponding coefficient in Fornell-Larcker criterion results in the respective row and column (Table 2). It can be concluded that the discriminating validity for the PEOs and PLOs is achieved.

Table 4. Fornel-Larcker Criterion, Heterotrait-Monotrait Ratio and Cross Loadings Results

Construct	PEOs	PLOs
Fomell-Larcker criterion		
PEOs	**0.744**	
PLOs	0.606	**0.900**
Heterotrait-Monotrait ratio		
PEOs		
PLOs	**0.633**	
Cross-loading		
PEO1	**0.864**	0.457
PEO2	**0.870**	0.472
PEO3	**0.923**	0.605
PEO4	**0.942**	0.617
PLO1	0.356	**0.710**
PLO2	0.477	**0.807**
PLO3	0.444	**0.716**
PLO4	0.382	**0.758**
PLO5	0.432	**0.729**
PLO6	0.315	**0.759**
PLO7	0.474	**0.765**
PLO8	0.518	**0.738**
PLO9	0.586	**0.747**
PLO10	0.393	**0.700**

Meanwhile, the results of the Heterotrait-Monotrait (HTMT) ratio in Table 4 shows that the correlation coefficient of PEOs-PLOs was 0.633. As suggested by [17], that constructs of less than 0.90 indicates that all constructs are distinct from each other, and henceforth the measurement model shows sufficient discriminating validity.

In conclusion, the measurement model is acceptable in response to evaluations based on criteria as suggested by [17].

C. Assessing of the Structural Model

As suggested by [17], the collinearity between constructs, the significance of the path coefficient, the coefficient of determination (R^2) values, the f^2 effect size, and the predictive relevance (Q^2) are examined in order to assess the structural model in PLS-SEM.

Collinearity Between Constructs

The study assessed the collinearity between constructs by examining the Variance Inflation Factor (VIF) of indicator variables.The VIF value of less than 5.000 indicates no collinearity between constructs. The study revealed that the VIF value ranges from 1.000-4.453 for all the indicator variables as shown in Table 5. This shows that there were no collinearity (redundancy) between all the constructs.

Table 5. The Variance Inflation Factor of the Indicator Variables

Indicator Variables	PEO1	PEO2	PEO3	PEO4	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO
VIF	2.623	2.687	3.613	4.453	2.322	3.229	2.003	3.428	2.084	2.690	2.440	2.064	2.133	1.965	1.000

The Significance of the Path Coefficient

In assessing the path coefficient, the bootstrapping method was utilized. In this study, 90 cases was run using 500 bootstrapped samples which recommended by [17]. Fig. 2 shows the result of bootstrapping analysis for the PLS-SEM.

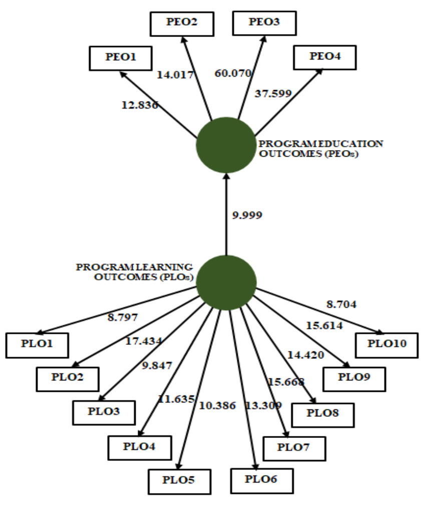

Fig. 2. Bootstrapping Analysis for the PLS-SEM

The assessment of the significance and relevance of relationships in the structural model shows that there was a significant relationship between PLOs and PEOs (β= .606, $t(88) = 9.995$, $p < .001$).

The Coefficient of Determination (R^2 Value)

The amount of variation in PEOs described by the model was determined by assessing the R^2 value. The study revealed that the R^2 for PEOs was 0.367 as shown in Fig. 1, which implies that 36.7% of variation in PEOs was explained by the PLOs. In conclusion, the structural model describes reasonably well the amount of variation explained by the exogenous construct (PLOs).

Effect Size, f^2

In addition to evaluating the R^2 value, the change of R^2 value in multiple independent variables on the dependent variable, when a specified exogenous construct is omitted from the model can be used to evaluate whether the omitted construct has a substantive impact on the endogenous constructs. This can be done by utilizing f^2 [17]. However, since there was only a single independent variable (PLOs) in this study, f^2 analysis was not performed. The study only referred to R^2 value in evaluating the structural model.

Predictive Relevance, Q^2

The blindfolding procedure was performed to calculate the predictive relevance (Q^2) of the model fit. The Q^2 shows how well observed values/indicator variables are reconstructed by the model and the parameter estimates [20]. [17] stated that Q^2 is deemed to be of predictive significance higher than zero. The results of blindfolding of the measure of predictive relevance is shown in Table 6.

Table 6. Blindfolding Results of the Measure of Predictive Relevance

Construct	Cross-validated	SSO	SSE	Q^2(1-SSE/SSO)
PEOs	Redundancy	360	262.493	0.270
	Communality	360	134.930	0.625

* SSO: Sum of square observations
SSE: Sum of square errors

For this study, the Q^2 was greater than zero for both cross-validated redundancy and communality indicating that the PLOs had predictive relevance for the endogenous construct (PEOs), thus the structural model should be able to provide a prediction of the indicator of the endogenous construct.

V. CONCLUSION

The study prosperously developed and evaluated the PEOs and PLOs relationship by means of structural equation model through PLS-SEM. The measurement model and structural model were validated using empirical data and met the criterion suggested by [17]. The study revealed a relationship between PEOs and PLOs, and the findings were in tandem with [10], [11], and [12]. The results indicated that the relationship of PEOs and PLOs was statistically significant. These findings were also supported by other studies such as [13] and [14]. The results designated that the developed model was fortified by empirical analysis and in parallel to the antecedent findings and theoretical framework. In conclusions, the relationship of PEOs and PLOs is not only can be expressed qualitatively but it can additionally be modeled in structural form as highlighted in this paper.

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