Outcome based Education Performance Assessment: A Computational Model to measure Electrical Engineering subjects Learning Outcomes

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Abstract: - Engineering Accreditation Council of Malaysia (EAC) adopts the American Accreditation Board of Engineering and Technology 2000 (ABET) requirements which promote outcome based education (OBE) learning process. OBE calls for the evaluation of the subjects learning outcomes (LO) as specified in the Programme Specification. This good practice is implemented in the Faculty of Electrical Engineering, Universiti Teknologi Malaysia (FKE) teaching and learning processes which was duly certified to ISO 9001:2000. Evaluation method has been largely dependent on students' performance carrying out tasks such as tests, quizzes or submission of assignments. Evaluation on the performance outputs; categorised as technical knowledge and generic skills, gives an indication on the achievement of the subject expected LO. Technical knowledge is largely taken care of by the Final Exam papers. However, evaluation of generic skills remain vague. This paper describes a measurement model which can be used to measure a subject LO of an undergraduate electrical engineering subject. An overview of the measurement model and its key concepts are presented and illustrated using assignments given through SEE 2523 - Electromagnetic Field Theory. The assignments were evaluated on how well it relates to the generic skills dimension being assessed and scrutinised, whether it correspond to the LO that is to be measured. The model has a simple framework where an evaluation form was designed showing each dimension of the generic skills to be assessed. Attributes for each dimension were duly identified and coded dichotomously to clearly define the assessment. Results obtained were assessed against the course LO maps for consistency and used as a guide for future improvement of the teaching method and style. The study shows that this model of measurement can classify grades into learning outcomes accurately with only very few randomly selected dimensions.

Key-Words:- Learning Outcomes, instructional objectives, performance assessment, Quality, continuous improvement.

1 Introduction

A major impetus for the performance assessment movement has been the need to reconnect large-scale and classroom assessment to mapped learning outcomes (LO) so that assessment affects learning positively thus enhancing instruction in classroom. When we are better informed of the subjects learning outcomes, hence, progress and difficulties of the students, it will serve as a good guide for us to make quality decisions about what a student needs to learn next and how to teach that material in a manner that will maximize the student's learning. This knowledge enrichment process is vital to inculcate students' zest for knowledge.

In education we make three (3) types of decisions using assessment results [1]:

1. Instructional placement decisions: what the student knows and where he or she should be in the instructional sequence i.e., what to teach next.
2. Formative evaluation decisions: information to monitor an engineering student's learning while an instructional program is underway; how quickly progress is being made, whether the instructional program is effective, and whether a change in instructional program is needed to promote the engineering student's learning.
3. Diagnostic decisions: which specific difficulties account for the engineering student's inadequate progress so a tutor or lecturer can remediate learning progress and design a more effective instructional plans.

In the Faculty of Electrical Engineering, Universiti Teknologi Malaysia (FKE), a series of assessment in the form of tests, quizzes, and final examination were designed to validate such learning outcomes which is primarily defined by Bloom's Taxonomy [6,17] for cognitive skills measurement.

However, a good education system should generate graduate engineers who are 'ingenious'; that are also able to think creatively, take calculated risks and adopt exploratory attitudes; collectively termed as generic skills. A graduate is deemed to be of competence when they possess good interpersonal skills, oral and written communication, leadership skills, teamwork, problem solving, creativity and sound computer literacy [13]. This behaviourial measurement on engineering students affective conduct is rarely considered. In view of the degree of importance, it is surprising that the need for affective measurement has not attracted wider attention within the institution of higher learning community.

The Faculty of Electrical Engineering, UTM (FKE) subscribes to the OBE learning process in the effort to meet the requirements of the American Accreditation Board of Engineering and Technology 2000 (ABET). Thus, a thorough method of measurement; both cognitive and affective, is required to gauge the achievement of the expected Learning Outcomes (LO) of the subject effectively.

This paper presents a model of performance measurement for such generic skills using SEE 3512 Electromagnetic Field Theory 1 (EMT- 1) as an illustration, to establish their Affective Learning Capability Indicator; ALi which can be used to decide the necessary course of action to achieve the desired level of generic skills through improved and more effective instructional plans. The assignment were evaluated on how well they relate to the content domain being assessed as stated in the course learning outcome and results were analysed to determine whether a gap exist in the engineering student's capabilities or psychological construct that is supposedly to be developed.

The model has a simple framework where an evaluation form was designed showing each dimension of the generic skills to be assessed. Attributes for each dimension were duly identified and coded dichotomously to clearly define the assessment.

2 Background: An Overview of Performance Assessment

Performance assessment is relatively new, undeveloped and yet to be studied systematically. Many practitioners are experimenting with its use and contributing to its development and refinement. Yet they are often in the undesirable position of interpreting vague design features and operationalizing those features into specific assessments on their own. These assessments take a variety of forms, some of which are closer than others in approximating the conceptual and theoretical underpinnings of performance assessment. Criteria of a good assessment include;

1. Measure important learning outcomes. The extent to which performance assessment measures important learning outcomes depends on the specific assessment problem or task. Performance assessment tasks should reflect important, realworld performances that are tied to desired student outcomes that are relevant to the workplace and everyday life. They should connect meaningfully with specific instructional methods that can be realistically managed in classroom settings.
2. Address all the three(3) purposes of assessment. It is unclear how performance assessment can be used to formulate instructional placement or formative evaluation decisions. Ideally, alternate forms of the problem could include the same concepts administered over time in order to yield information about individual students' progress. Although performance assessment offers the promise of addressing all the three assessment purposes, specific methods for doing so have yet to be developed.
3. Provide clear descriptions of student performance that can be linked to instructional actions. When performance assessment tasks address a variety of concepts in

age-appropriate, realworld situations, lecturers can form a picture of student performance across skills and identify the student's problem-solving strategies. However, this depends on the lecturer's skill in identifying student competencies, gleaning information about students' strategic behavior, and relating these observations to specific instructional techniques. Consultation methods or computerized strategies for generating profiles of student competence are needed.

4. Compatible with a variety of instructional models. Theoretically, performance assessment could be used with a variety of instructional approaches. Lecturers should experiment with a variety of instructional methods as they implement performance assessment, especially with students who have serious learning problems.
5. Easily administered, scored and interpreted by fellow lecturers. Performance assessment can require large amounts of lecturer's time to design and administer. It is easy to see how this type of assessment could generate many different types of intervention plans for different students in a classroom size of 20 or 30. A lecturer would be unable to manage this situation effectively. Performance assessment developers need to solve the problem of how to implement intervention plans based on performance assessments within the constraints of a classroom ambiance.
6. Communicate the expected learning outcome to Lecturers or Tutors as well as students. When it is clearly apparent that an assessment is aligned with instructional goals, lecturers should be able to use that assessment to direct their instruction, and students should be able to use it to achieve the determined subject learning outcomes. This depends, however, on the extent to which the scoring rubric used is clear, concrete and visible.
7. Generate accurate, meaningful information i.e., be reliable and valid. Performance assessment represents a vision that can shape the future direction of classroom-based assessment, but it requires much additional scrutiny and development before it can fulfill its promise.

Performance assessment can be viewed in the correlational ABC Model on how cognitive skills and affective state is reflected in the behaviour of students during learning. Weybrew, 1992 discussed at length on the repercussion of such development but believed that affective values is of significant importance in neuro-linguistic programming otherwise popularly known as NLP [2].

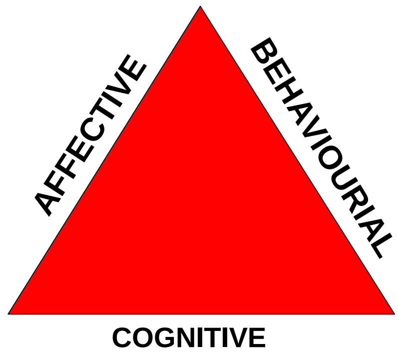

Figure.1 ABC Model

3 Measurement Methodology

This study addresses the following questions:

1. Does this measurement model result in accurately classified examinees?
2. Are the dimensions and attributes used effective and can generate maximum information on the student's ability ?
3. How many dimensions need to be captured to make accurate classifications?
4. How many examinees are needed to satisfactorily calibrate this measurement model?

A method of defining the required metrics in Performance Assessment is setforth modelled on Razimah (*2006*) Plan-Execute-Report-Monitor (P-E-R-M) assessment method to measure the Value for Money (VFM) Audit performance [3]. This model is found very much agreeable to Shewhart's (*1939*) P-D-S-A Cycle which was subsequently developed into the infamous Deming's (*1954*) P-D-C-A Cycle by the Japanese industrial community. Then, in year 2000 in Geneva, this fundamental concept was adopted by the international community in ISO9000 and other subsequent series.

The statistical approach employed is simple yet it can yield very accurate findings using data-driven approach to analyse the root causes of each learning problem encountered [4]. It is a very disciplined approach for assessing students generic skills during a learning process. Communication skill, teamwork, life long learning etc. are generic skills which we shall term as dimensions.

Within these dimensions, relevant main areas or attributes, related to the learning outcome is then identified but not limited to viz; vocabulary power, technical appreciation, software development and resourcefulness. Collectively this is known as attributes which are measurable [5].

The assessment form is designed and developed for the attributes which is rated based on an even number scale of 1 – 6 dichotomously indicating NO – YES with 2,3 – 4,5 indicating their level of agreement to an attribute. This assessment form gathers empirical data as the main instrument of this study. Table 1 shows the conceptual format of the designed assessment form.

Table 1: Tabulation of Assessment Criteria

PERFORMANCE SCORE FORM Student: *XXX YYY* Date: ddmmyy								
Ratings	***W***	**GRADE**						**W*G**
		1	**2**	**3**	**4**	**5**	**6**	
Dimension A								
Attribute A1								
Attribute A2								
Attribute A_n								
Dimension B								
Attribute B1								
Attribute B2								
Attribute B_n								
	Sum (W*G)							

Dimension A, B…n, are the generic skills to be assessed. These are, but not limited to, communication skills, resourcefulness, adaptabilty etc. The attributes are finite skills within each dimensions. In report writing, the attributes would be grammatical order, logic flow or reasoned arguments. Due grade is given for each attribute during assessment by the lecturers. Thus, a holistic discrete method of measurement can be developed to enable the respective mean, $\bar{x}$, values for each generic skills can be established [6]. These values will serve as an indicator and gives a locii on the quality level of the subject learning outcomes.

Table 2 shows the simple computation of an assessment. The lecturer will give his evaluation on the student's performance using the prescribed form. He will give his own weightage, W for each dimension. This allows flexibility and freedom for each lecturer to make his own evaluation. This is vital because the lecturer is free to set his own criteria of assessment and let the student know what is expected from the assignment. Next each attribute is given a grade. In this exhibit, the grade of attributes in Dimension A is totalled up:

Attribute A_n= 4+5+6 =15 (1)

The sum of the grades is then averaged out; to give

Dimension A Average Score, $^{15}/_{3}$ = 5 (2)

This raw Average Score; Ave.S=5 is adjusted by multiplying W, weightage to give the actual score for the said dimension;

Dimension A score, W*G = 0.4 x 5 = 2 (3)

Finally, each Dimension score is summed up to give the actual score the student obtained for his assignment;

Sum (W*G) = (0.4 x 5) +(0.6 x 4) (4)
= 2.0 + 2.4
= 4.40

This actual score is more reflective of the students' generic skill ability rather than arbitrarily assessed.

Table 2. Simulated Assessment

PERFORMANCE SCORE FORM Student: *XXX YYY* Date: ddmmyy								
Ratings	***W***	**GRADE**						**W*G**
		1	**2**	**3**	**4**	**5**	**6**	
Dimension A	40							0.4x5=2
Attribute A1					_/			Ave.S=
Attribute A2						_/		4+5+6 / 3
Attribute A_n							_/	= 5
Dimension B	60							0.6x4=2.4
Attribute B1				_/				Ave.S=
Attribute B2					_/			3+4+5 / 3
Attribute B_n						_/		= 4
	Sum (W*G)							2+2.4 = 4.4

Table.3 shows a further simulated computation to establish the subject learning outcome index of Dimension A; A-LO_i . Let us assume the total number of student in a cohort is 100, hence, N of the population surveyed; N=100. The spread of N for each attribute is;

Attribute A1: 5, 20, 35, 25 and 15

Attribute A2: 10, 25, 40, 20 and 5

This value of N is multiplied to each respective grade;

2x5 =10, **3**x20 =60, **4**x35 =140,
5x25=125, **6**x15 =90 (5)

This gives a sum of;

10 + 60 + 140 + 125 +90 = 425 (6)

The total score for Attribute A1,N=100 =425, is then moderated against the full score in an ideal scenario when everybody is totally assessed excellent.; hence, $^{425}/_{600}$ = 0.71. The mean value $\bar{x}$ for this particular attribute is obtained by multiplying this value of 0.71 to the expected full score of 6 to proportionately yield a value of 4.25.

Table 3. Learning Outcome Analysis

LEARNING OUTCOME ANALYSIS Subject: *XXX YYY* Date: ddmmyy							
Rating	**1**	**2**	**3**	**4**	**5**	**6**	$\bar{x}$
Dimension A							
Number of N	0	5	20	35	25	15	100
Attribute A_1 Score Obtained		10	60	140	125	90	$\frac{425}{100}$ =4.25
Number of N	0	10	25	40	20	5	100
Attribute A_2 Score Obtained		20	75	160	100	30	$\frac{385}{100}$ =3.85
$\bar{x}_i =$							$\frac{4.25+3.85}{2} = 4.05$
Dimension A Learning Outcome Score: A-LO*ᵢ*							$\frac{4.05}{6} \times 100$ = **67.49%**

This process is repeated for all the other attributes to give each mean value of Dimension A $\bar{x}_A$ value ;

$$\frac{\text{Sum of } \bar{x}_{An}}{\text{Total number of attributes}}$$

$$\frac{4.25 + 3.85}{2} = 4.06 \qquad (7)$$

Next, proportionate the result by 6, being the full score, to obtain the subject Dimension A -Learning Outcome indicator, **A-LO$_i$** ;

$$\frac{4.06}{6} \times 100 = 67.49\% \qquad (8)$$

Upon completion of computing each attribute **n-LO$_i$,** both attributes $\bar{x}$ and **%-LO$_i$** is tabulated to establish the subject LO as shown in Table 4.

Table 4. Subject Learning Outcome Analysis

SUBJECT LEARNING OUTCOME SUMMARY Subject: *XXX YYY* Date: ddmmyy							
Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**%-LO$_i$**
Dimension A	4.25	3.85					**67.50**
Dimension B		3.66	3.28	3.66			**58.89**
Dimension n_3			3.66		3.66	4.18	**63.89**
Dimension n_i	3.66			4.32		3.71	**64.94**
Attribute $\bar{x}$	**3.96**	**3.76**	**3.47**	**3.99**	**3.66**	**3.95**	
Subject LO $\bar{x}_i = \frac{\Sigma \text{ Attributes } \bar{x}}{\text{Total No. Attributes}}$							$\frac{22.79}{6}$ $\bar{x}$= 3.80
Subject Learning Outcome Score $= \frac{\Sigma \text{ Dimension \%-LO}_i n}{\text{Total No. Dimensions}}$							$\frac{255.22}{4}$ = **63.33%**

Each dimension attribute $\bar{x}$ is first determined, say subject Then, a similar computaion to (7) is executed to find the subject LO $\bar{x}$ value by summing up each dimension attribute instead;

$$\frac{\text{Sum of Attributes } \bar{x}\ D_n}{\text{Total number of attributes}}$$

$$\frac{3.96+3.76+3.47+3.99+3.95}{6} = 3.80 \qquad (9)$$

Finally the subject LO, **SLO$_S$** can now be established by similar computation in (8);

$$\frac{3.80}{6} \times 100 = 63.33\% \qquad (10)$$

4 Discussion

Now a comprehensive pro-forma evaluation for the required quality attributes known by dimensions and attributes can be prepared to meet ABET LO evaluation requirement.

This method of evaluation is able to reveal many vital informations which was previously hidden in the traditional raw score markings. Many areas can be further explored upon compilation of sequential data set for the program future longitudinal evaluation.

As shown in Table 4, assuming FKE set 60% as the threshold as qualifying mark, it is observed that FKE is having trouble with Attribute 3 where $\bar{x}$ < 3.60. Similarly LO –B < 60% does not meet the criteria setforth. This method of evaluation enable better assessment of Learning Outcome score and if it reveals symptoms of weaknesses in certain attribute or LO; i.e. generic skill trait, this can be traced more effectively and easily.

The lecturer can immediately focus on the exact problem to be resolved. FKE Academic Council now know exactly the nature of the problem each lecturer has in delivering the service. Academic management in FKE is now made easier and actions can be taken more effectively. Formative evaluation decisions on the need for change in instructional program can be carried out more effectively. A summary report on the whole program status is shown in Table 5.

The monitoring and measurement of teaching and learning process can be improved dramatically using this method. The computation can be done by simple Excel macros and report generated is found to be a very useful management tool in FKE.

Students' weakness is easily and clearly identifiable. FKE management found the information generated from this analysis very meaningful for correct instructional placement decisions. Diagnostic decisions to attend specific area where student encounter difficulties in learning can be directed to the respective lecturers who can remediate students'learning progress and design a more effective instructional plans [7].

Table 5. PROGRAM LEARNING OUTCOME MAP

PROGRAM COURSE LO'S MAP							
Program: SEE					Sem:02 Yr:2007		
COURSE	LO'S						%
	1	2	3	4	5	6	
SEE 2523	3.96	3.76	3.47	3.99	3.66	3.95	**63.33**
SEE 2624							
SEE 2768							
SEE 2893							
SEE 2884							
SET 1683							
Σ COURSE LO							

This method of simple measurement will help guide the faculty academic management to respond with certainty on the nature of corrective actions to be taken. On the other hand, a more balanced reporting is developed where the system accomplishment is equally recognized. Since the discrete value of score uses $\bar{x}$ as the scale of measurement, the standard deviation, ∂, of these values can be further identified. More detailed analysis can be done to make this reporting method very comprehensive.

5 Conclusion and Recommendations

This simple but prudent conceptual theoretical framework to establish the subject learning outcome shall be able to provide a more comprehensive view but specific and objective in evaluation. Discrete method of measurement are more reliable and information generated thereof is certainly valid [8].

Dimensions affecting the performance of a teaching method shall be subjected to further study and the attributes in relation thereof which has material effect on the teaching and learning system must be subsequently researched thoroughly in the near future to give a more accurate account of the subject learning outcome.

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