Outcome Based Education Performance Measurement: A Rasch-based Longitudinal Assessment Model to measure Information Management Courses LO's

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Abstract:- Malaysia Qualification Framework, 2005 (MQF) promotes outcome based education (OBE) learning process. OBE calls for the evaluation of the course's Learning Outcomes (CLO) as specified in the Program Specification. This good practice is implemented in the Faculty of Information Technology and Quantitative Science, Universiti Teknologi MARA (FTMSK) teaching and learning processes which was duly certified to ISO 9001:2000. Assessment methods include giving students' tasks such as tests, quizzes or assignments at intervals during the 14 weeks study period per semester. CLO's were evaluated based on the students' performance which gives an indication of their learning achievements. Despite the marks obtained is orderly in manner, it is on a continuum scale. Hence, further evaluation using the raw score is rather complex to be carried out. This paper describes a Rasch-based measurement model as performance assessment tool to measure the CLO. Rasch Model uses 'logit' as the measurement unit thus transforms the assessment results into a linear correlation. An overview of the measurement model and its key concepts were presented and illustrated. An assessment form using Bloom's Taxonomy as parameter was designed showing each dimension of the ability to be measured. The results there from were evaluated on how well it relates to the attributes being assessed and scrutinized. It is further checked against the CLO Maps for consistency and used as a guide for future improvement of the teaching method and style. This provides the lecturers a more accurate insight of the student level of competency achieved. The study shows that this model of measurement can classify students' grades into linear competency scale accurately using only very few primary data sets to enable corrective action to be taken effectively at the early stage of learning.

***Keywords*:** Learning Outcomes, performance assessment, evaluation, competency, Bloom's Taxonomy, quality.

1 Introduction

A major impetus for the performance assessment movement has been the need to reconnect large-scale and classroom assessment to mapped CLO's so that assessment affects learning positively thus enhancing instruction in classroom. When we are better informed of the CLO's, 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 information management education we make three(3) types of decisions using assessment results[1]:

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

In the Faculty of Information Technology and Quantitative Science, Universiti Teknologi MARA (FTMSK), a series of assessment in the form of tests, quizzes, and final examination were designed to validate such CLO's which is primarily defined by Bloom's Taxonomy for skills measurement [2]. It has been argued that, a good education system should generate graduates in information management who are 'ingenious'; that are also able to think creatively, take calculated risks and adopt exploratory attitudes; collectively termed as affective or 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. This behavioral measurement on students' affective conduct is sometimes not given enough emphasis. Response from the industry could provide clear indication of any gaps on graduates' generic skills since this is crucial for them to secure jobs in an already very stiff market. In view of its importance, the need for skill based measurement is already gaining wider attention within the institution of higher learning community.

FTMSK, for example, observed the MQF Guideline, Malaysian Institution of Higher Learning Quality Assurance (JK-IPTA, 2005) which provides the CLO framework to be assessed. Thus, a thorough method of measurement; both cognitive and affective, is provided by the Guideline to gauge the achievement of the expected CLO of the subject effectively.

This paper presents a model of performance measurement for such abilities using Rasch-based evaluation tool to establish their Learning Capability Indicator; $\mathbf{CL}_i$ which can be used to decide the necessary course of action to achieve the desired level of competency through improved and more effective instructional plans. The final examination paper; ITS754 –Decision Support System for Sem.1- 2007/08 was evaluated on how well they relate to the content domain being assessed as stated in the CLO and results were analyzed to determine whether a gap exist in the information technology student's capabilities or psychological construct that is supposedly to be developed.

The model employed a simple framework where an assessment form utilizes the Table of Test Specification designed on Bloom's Taxonomy parameters showing each dimension of the ability to be assessed.

2 Background: An Overview on 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. These assessments take a variety of forms, some of which are closer than others in approximating the conceptual and theoretical underpinnings of performance assessment. Fuchs (1995) explained in great details the criteria of a good assessment in education, but not limited to;

a. Measure important LO's
b. Address the prime purpose of assessment.
c. Provide clear descriptions of student performance that can be linked to instructional actions.
d. Compatible with a variety of instructional models.
e. Easily administered, scored and interpreted by fellow lecturers.

f. Communicate the expected learning outcome to Lecturers or Tutors as well as students.
g. Generate accurate, meaningful information i.e., be reliable and valid.

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 [3].

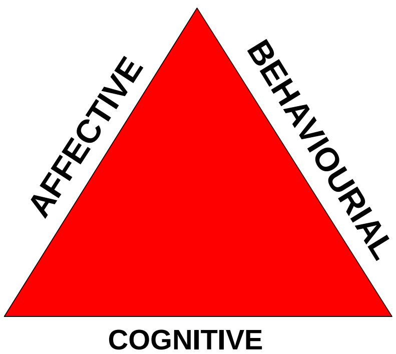

Figure.1 ABC Model
Source: Weybrew, 1992

3 Measurement Methodology

This study addresses the following questions:

a. Does this Rasch-based model result in more accurately classified examinees?
b. Is Bloom's-based Table of Test Specification effective in generating meaningful information on the student's ability? and,
c. How many examinees are needed to satisfactorily calibrate this measurement model to competency?

A method of defining the required metrics in an institution of Higher Learning Performance Assessment is set-forth modeled on Aziz (*2004*) Plan – Implement – Check – Evaluate (P-I-C-E) assessment method to measure the effectiveness of a system performance [6]. 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 through the implementation of ISO9000:2000. McLelland (1995) developed the Knowledge-Skill-Ability- Others (KSAO) model on the same format to define competency.

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. It is a very disciplined approach for assessing students' ability during a learning process. Cognitive skills are clustered on and extended to include the affective skills; i.e. communication skill, teamwork, life long learning etc. These skills shall be termed as dimensions. Bloom's taxonomy is applied for this purpose.

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.

Table 1 shows the conceptual format of the designed CLO. It has dual purpose; first is to define the CLO and enumerate the focus of teaching and, second, serve as a guide for the preparation of an assessment.

Table 1. Pro-Forma Learning Outcome Map

COURSE LO'S MAP Course: ABC1234 Course XYZ Sem:02 Yr:2007									W
Topics	M	LO'S							
		1	2	3	4	5	6	7	
Topic A									45
Sub-topicA1		3				2			
Sub-topicA2			1			2			
Sub-topicA$_n$			2	1					
Topic B									55
Sub-topicB1		2			2				
Sub-topicB2			2	1					
Sub-topicB$_n$				2	1				
Σ COURSE LO%		10	25	30	20	15	-	-	100

TEACHING FOCUS: 1-Minor 2-Mediocre 3-Major
M – Marks W - Weightage

Each topic to be taught will be given a Teaching Focus rated 1 as Major, 2 for Mediocre and 3 for Minor. This provides a guide for lecturers to prepare their teaching plan focus, on how much time to be spent for each topic covered. The column on the right most; W% – show the spread of focus given; say Topic A: Introduction; less time whilst Topic B – Concept Outline; is given more time. The bottom row shows the spread of teaching focus; giving the indication which CLO is the centre of attention. Inverse diminishing scale, $\frac{1}{2^n}$ is used to calculate the Total Sum of CLO teaching focus with the following designated scores; Major; $\frac{1}{2^0}=1$, Mediocre; $\frac{1}{2^1}=0.5$ and Minor; $\frac{1}{2^2}=0.25$ respectively.

Column marked M is used as control for mark distribution during the design of assessment questions. At this point, the CLO is turned into the Table of Test Specification based on Bloom's Taxonomy. The bottom row serves as a guide on the spread of questions to be prepared; where 15% will come from BT1- Knowledge, 35% from Understanding, 25% from Application, 15% from Analysis and 10% from Evaluation. In this case a database of Questions Item Bank is available where questions were earlier vetted and readily available for selection. ABET Guide was used to transform the CLO's into Blooms Taxonomy [4]. Refer Table 2 for transformation matrix.

Table 2. Transformation of CLO into Bloom's

TABLE OF TEST SPECIFICATION
Course: ABC1234 Course XYZ Sem:02 Yr:2007

Topics	M	BLOOM'S TAXONOMY						W%
		BT1	BT2	BT3	BT4	BT5	BT6	
Topic A								
Sub-topicA1		3	2					45
Sub-topicA2			1			2		
Sub-topicA$_n$			1	2				
Topic B								
Sub-topicB1				2	2			55
Sub-topicB2			2	1				
Sub-topicB$_n$		1			2			
QUESTION SPREAD %		**15**	**35**	**25**	**15**	**10**	**-**	**100**

This is the vital pivot point on the scale of measurement academician must observe. First, we have put all the items on the same criteria of measurement. Bloom's Taxonomy is the common reference criteria used in education. Second, the lecturers have all the freedom to decide on the distribution of questions to be set but using Table 3. Table of Test Specification percentage of question spread as the framework of questions asked.

The lecturers can now assess the student's performance using this framework. 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 students.

Upon completion of the test, results were analysed for reliability using Rasch Separation Index –***G*** and One Parameter Item Response Theory Difficulty Index '***b***' for construct validity – the instrument used, i.e. the exam paper is measuring what it should be measuring. Hence, data can be duly analysed for further meaningful interpretation.

Table 3. *pro-forma* Table of Test Specification

BLOOM'S vs LO Matrix
Course: ABC1234 Course XYZ Sem:02 Yr:2007

	CLO'S							W%
	1	2	3	4	5	6	7	
BLOOM'S TAXONOMY								
Knowledge -**BT1**	3		1					**15**
Understanding -**BT2**	2	1	1	2				**35**
Application -**BT3**		2		1	2			**25**
Analysis -**BT4**			2		2			**15**
Evaluation -**BT5**		2						**10**
Synthesis -**BT6**								-
Σ COURSE LO %	**10**	**25**	**30**	**20**	**15**	**-**	**-**	**100**

However, raw score obtained from quizzes, tests, assignments and final exam are continuum scale. It has an order but does not possess an interval scale. Hence, further evaluation using the raw score is rather complex to be carried out. Raw score has the limitation of telling exactly the extent of skills development. A student who scores 80% cannot be deduced to be twice as smart as a student who scores only 40%. A test score cannot classify examinees into the correct ability group for remedial measures. Cronbach-alpha and Factor analysis works on historical data. Rasch Model is a predictive model to give an indicator on a scale where the student is in a cohort. All the error in measurement is absorbed in Rasch Model which uses '*log odd units' (logit)* as the measurement unit thus transforms the assessment results into a more accurate linear correlation.

In this exhibit, students sat for a series of assessment, in this case the final exam paper; ITS754 –Decision Support System. The Final Examination paper gathers empirical data as the main instrument of this study.

Dimensions A, B…*n,* where n = skills to be assessed based on defined Bloom's Taxonomy; i.e. ability to acquire sound knowledge in Decision Support System, understanding given process and ability to apply appropriate knowledge; etc. Attributes are finite skills within each dimension. In a Support System, it would be process order, logic flow or the components required in a decision-making process, Decision Support System (DSS), group DSS and expert system.

Thus, a holistic discrete method of measurement is developed to enable the respective mean, $\bar{x}$, values for each skill can be established [5]. These values will serve as an indicator and gives a locii on the quality level of the CLO's. Table 4 shows the respective CLO's for ITS754 – Decision Support System.

Table 4. ITS754 –Decision Support System CLO's

Series	Course Learning Outcomes
CLO 1	**Acquire** knowledge components required of a decision-making process, Decision Support System (DSS), group DSS and expert system.
CLO 2	**Determine** the differences between individual, group and enterprise decision-making processes.
CLO 3	**Understand** the required principles of DSS and other techniques in a real-world projects.
CLO 4	Creative applications to **solve problems** in complex, unstructured ambiguous situations under conditions of uncertainty.
CLO 5	Apply high power of **critical analysis** shown by comprehensiveness of approach to decision making.
CLO 6	Critical **evaluation** of literatures on decision making.
CLO 7	**Synthesis** – a holistic understanding to deal with complexity and contradiction in the knowledge base through the application of multiple perspectives on IT managerial situations

The Final Exam paper was assessed to determine it's construct validity –whether it is functioning as an instrument to measure what is supposed to be measured; by way of Table of Test Specification. Each question was scrutinized to determine which CLO it belongs. Table 5 shows the distribution of marks by CLO and the respective percentage distribution.

It is noted that 65% of the question belongs to CLO 5-6; demanding critical analysis, evaluation and synthesis of decision making process. This is expected from students studying at Masters level.

Table 5. ITS754 -Table of Test Specification

CLO	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Mark by LO	%
1		`	2	8	4	5		19	13.57
2	5							5	3.57
3		12	2				4	18	12.86
4			4			3		7	5.00
5		8	12		16		6	42	30.00
6	15						10	25	17.86
7				12		12		24	17.14
Sum	20	20	20	20	20	20	20	140	100.00

The students' marks from the Final Exam taken are then tabulated as in Table 6. However, these marks are purely obtained from the counts on the number of correct answers for each question based on an approved Answer Scheme reviewed by FTMSK Academic Council. It is then sorted by CLO's and converts it into percentage so that it can now be easily inferred and reflect the student's degree of achievement by ability.

Table 6. Tabulation of Marks

TABULATION OF MARKS BY CLO								
Course: ITS754 Course: Decision Suport System Sem:02 Yr:07								
STU	LEARNING OUTCOMES SCORE							MARKS
	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6	CLO7	
ST01	9.0	0.0	6.0	7.0	20.0	0.0	14.0	**56.0**
ST02	6.5	0.0	10.5	6.0	26.0	0.0	17.0	**66.0**
ST03	7.0	5.0	4.0	2.5	15.0	18.5	19.0	**71.0**
ST04	9.0	5.0	11.5	4.0	31.0	10.5	10.0	**81.0**
ST05	9.0	5.0	16.0	3.0	17.0	23.0	12.0	**85.0**
ST06	10.5	0.0	6.0	7.0	26.0	0.0	22.0	**71.5**
ST07	11.0	0.0	15.0	3.0	26.5	0.0	22.0	**77.5**
ST08	15.0	5.0	10.0	3.0	18.5	15.0	22.0	**88.5**

Table 7 shows the tabulation of marks in terms of percentage to show the achievement for each CLO. The result shows a very conspicuous and

Table 7. ITS754 Adjusted Raw Score(%) by CLO

Student	RAW SCORE (%) BY LEARNING OUTCOMES Course: ITS754 Session: SEM 2/2007-08							
	DIF	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6	CLO7
ST01	1	47.4	-	33.3	100	47.6	-	58.3
ST02	2	34.2	-	58.3	85.7	61.9	-	70.8
ST03	1	36.8	100	22.2	35.7	35.7	74.0	79.2
ST04	1	47.4	100	63.9	57.2	73.8	42.0	41.7
ST05	2	47.4	100	88.9	42.9	40.5	92.0	50.0
ST06	2	55.3	-	33.3	100	61.9	-	91.7
ST07	1	57.9	-	83.3	42.9	63.1	-	91.7
ST08	2	79.0	100	55.6	42.9	44.1	60.0	91.7

revealing fact about the students performance. Students is having problem grasping CLO-3: Understand the required principles of DSS and other techniques in a real-world projects. It is also interesting to note that ST03 is facing a very serious problem in CLO-1 and CLO-3:CLO5 despite obtaining a total raw score of 71 marks. This is among the power of CLO assessment as compared to Classical Classroom Assessment.

The data need to be transformed to enable further analysis using Rasch Model. Table 8 shows a simple conversion of Table 7- CLO equivalent final exam scores into rating scale; in this case broken into five categories, the rationale of which has been shown in previous works [5, 6]

Table 8. ITS754 Rated Score by CLO

Student	RATED SCORE BY LEARNING OUTCOMES Course: ITS754 Session: SEM 2/2007-08							
	DIF	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6	CLO7
ST01	1	1	0	0	5	1	0	2
ST02	2	0	0	2	5	3	0	4
ST03	1	0	5	0	0	0	4	4
ST04	1	1	5	3	2	4	1	1
ST05	2	1	5	5	1	1	5	2
ST06	2	2	0	0	5	3	0	5
ST07	1	2	0	5	1	3	0	5
ST08	2	4	5	2	1	1	3	5

Grade Rating: %Marks >80=**5** >70=**4** >60=**3** >50=**2** >40=**1** <40=**0**

A DIF –Differential Item Functioning is also introduced here; in this case is the gender where Male=1 and Female=2. The underlying principle is to verify that the question asked does not discriminate the students irrespective of gender.

For clarity purposes, let us assume the total number of respondent; N=100 and the skills to be assessed is **CLO 7** –Synthesis. Table 9 shows the detailed simulated computation to establish the CLO indicator; LO_i .

Imagine, the spread of *N* for each attribute given the grade rating $G_{1\text{-}4}$ is;

Attribute A_1, *N*: 15, 30, 35 and 20
Attribute A_2, *N*: 25, 40, 25 and 10; etc.

Next, this value of *N* is multiplied to each respective grade rating;

$$15 \times \mathbf{1} = 15,\ 30 \times \mathbf{2} = 60,\ 35 \times \mathbf{3} = 105,\ 20 \times \mathbf{4} = 80 \quad (1)$$

This gives a total sum rawscore of ;

$$15 + 60 + 105 + 80 = 260 \quad (2)$$

Table 9. Computation of LO_i

COURSE LEARNING OUTCOMES ANALYSIS Course: ITS754 Session: SEM 2/2007-08						
Rating(R)	**1**	**2**	**3**	**4**	**5**	$\bar{x}$
Spread of **N**	15	30	35	20	100	
CLO-1 (R*N) Score Obtained	**15**	**60**	**105**	**80**	260	0.65
Spread of N	25	40	25	10	100	
CLO-2 (R*N) Score Obtained	**25**	**80**	**75**	**40**	220	0.55
	CLO Mean, $\bar{X}_i$ =				$\frac{2.40+2.20}{2} = 2.3$	
CLO$_i$: Course Learning Outcome Indicator					$\frac{2.30}{4} \times 100$ **= 57.50%**	

This can be expressed in equation form as:

$$\bar{x}_i = \sum_{x=0}^{k} p_{xi} x_i \quad (3)$$

where, k = maximum grade rating
P_{xi} = proportion of event for each Grade Rating
x_i = ascertained Grade Rating; $n=1,2,n_i \ldots n_k$

The frequency proportion of events where student obtained a certain Grade Rating is then established to compute the probability of achievement for each given CLO; i.e.CLO_i –Course Learning Outcomes indicator.

The ideal total sum score for Attribute $A_{1,N=100}$ =400, is then moderated against the full score in an ideal scenario when everybody is assumed to be totally excellent.;

$$\frac{260}{400} = 0.65 \quad (4)$$

The mean value $\bar{x}$ for this particular attribute is obtained by multiplying this value of 0.65 to the expected full score of 4 to proportionately yield a value of 2.40.

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

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

$$\frac{2.40+2.20}{2} = 2.30 \qquad (5)$$

Next, proportionate the result by 4, being the full score, to obtain the $\mathbf{CLO}_i$ score ;

$$\frac{2.30}{4} \times 100 = 57.50\% \qquad (6)$$

Detailed computation yields the students' CLO achievements for ITS754 –Decision Support System as tabulated in Table 10. Competency level achieved by each student for each CLO can therefore be dissected. This is where assessment by skilled based is more useful and meaningful. All students may have appeared to have passed the final exam; but Rasch measurement has shown it otherwise.

Table 10. CLO measurement: Rawscore versus Logit

Student	ADJUSTED SCORE ON LOGIT		
	DIF	RAW	CLO_P
ST01	1	56.0	*12.0*
ST02	2	66.0	*34.0*
ST03	2	71.0	*39.0*
ST06	1	71.5	44.0
MEAN	Item Mean, $\bar{x}$ =50. CLO mean		**46.0**
ST07	2	77.5	48.0
ST04	1	81.0	53.0
ST05	2	85.0	66.0
ST08	2	88.5	70.0

4 Findings and Discussion

Rasch Measurement offers a more in-depth analysis on the students' performance. Data on Table.7 reveals a very simple but clear picture on the flaw of Traditional Classroom Evaluation (TCE). We choose to walk away from the reality and put the blame on graduates for not meeting expectation when they join the workforce. Although TCE has it's own weakness, we are still compelled to produce graduates and assure our customers to provide excellent products continuously. If the analysis done in Table.7 based on 40% as the Accepted Quality Level for Competency is already disturbing, certainly it warrants a serious review into the teaching method and style currently deployed. Overtime the threshold level may be raised and ultimately the graduates are exceptional and will be above all.

It is also noted in Table.10 the True Score obtained by the students is not very encouraging as depicted by the raw score. The person mean= 46; i.e. the students' ability was found to be below the expected final examination difficulty index= 50. In fact ST01, ST02 and ST03 did not meet the criteria of the required CLO competency level. Details can be further evaluated using Rasch measurement by Item measure analysis to identify students who encountered a certain degree of difficulty in the learning process.

The power of Rasch measurement is undoubtedly omnipotent and capable to scrutinize the data by generating meaningful and vital information on students' abilities [7].

A comprehensive pro-forma evaluation for the required CLO known by dimensions and attributes can be prepared to meet MQF evaluation requirement. Student learning capability is indexed as an indicator to the CLO using Rasch Model.

In this case Rasch Model can be simplified as [8];

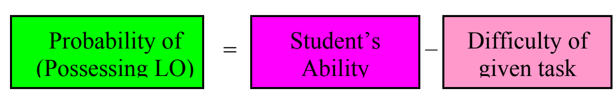

Fig. 1. Rasch Measurement – Detemination of Students' Ability

The Pr(PLO) value can be derived from score obtained in Table 10; hence the difficulty index. Rasch Model enable each of the Students' Ability; thus students' skill development to be clearly identified by each competency trait. Symptoms can be traced more effectively and treated specifically. This will help guide academicians to respond with certainty on the nature of corrective actions to be taken. Teaching methods may be reviewed and new approach is developed and tested. Teaching style may need some innovation to stimulate learning ambience.

The knowledge engineering and informatics algorithm can be taken up further from here on. Current work on Computer Adaptive Test incorporating the above parameters is making progress. Pilot test done thus far has been very promising and will serve as a very powerful tool to be employed in IT education particularly as well as education in Institutions of Higher Learning in the near future.

5 Conclusion and Recommendations

This simple yet prudent conceptual theoretical framework is capable of providing more comprehensive view but specific and objective evaluation. Rasch measurement model results in more accurately classified examinees. The students' competency gap with industry expectation can now be put under better control. Though the measurement model is able to show reliably accurate result even with small number *N*, the dimensions affecting the performance of a teaching method shall be subjected to further study and cross referenced to other fields of education [9]. ABET for example has been very aggressive in Engineering Education. 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 CLO.

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