



ALIGNING ASSESSMENT WITH OUTCOME BASED ASSESSMENT: AN EMPIRICAL STUDY ON UNDERGRADUATE COURSE ON FUNDAMENTALS OF STATISTICS

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Abstract:

Since the Institution of Engineers, Bangladesh (IEB) has made Outcome Based Assessment (OBA) compulsory towards program accreditation it has been one of the vital interests of most engineering departments in Bangladesh. When considering the mapping of the Course outcome (CO) to Program Outcomes (PO) implementation of the OBA may not be an easy task. This paper reports the analysis procedure of the CO and PO achievement for an B.Sc. course on Fundamentals of Statistics, a subject, which is part of curriculum of Electrical & Electronics Engineering and Computer Science and Engineering at Eastern University, Bangladesh. As a sum, this paper contributes complete process and an example investigation for Outcome Based Valuation starting from course curriculum progress to its CO-PO achievement based on definite criteria.

Keywords: outcome-based assessment, course outcome (CO), program outcome (PO), CO assessment, PO assessment

1. Introduction

Among engineering branches as Bangladesh signed in as provisional member of the Washington Accord through the Board of Accreditation for Engineering and Technical Education (BAETE) in 2006, the execution of Outcome Based Assessment (OBA) has been among the core attention of educational institutions in Bangladesh ([Baetebangladesh](http://Baetebangladesh.com)).

BAETE has constructed OBA execution as an obligatory exercise in order for the program to achieve accreditation. The execution of OBA is intention to achieve the

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university's mission and vision which shall confirm the syllabuses design achieves the program outcome and program education objective.

The perception of OBE is about emerging the curricular construction founded on what the student are anticipated to accomplish at the end of the B.Sc. Program ([Baetebangladesh](#)). In arrangement for OBE to be positively applied, there is a essential to take the basic mechanisms which are: (i) University Mission & Vision (ii) Program Educational Objectives (PEO); (iii) Program Outcomes (PO) and (iv) Course Outcomes (CO) ([Baetebangladesh](#)). OBA execution includes a steady and organized data collection procedure in the departments. In accumulation, the execution of OBA is composite as the charting of Course Outcome (CO) to PO may not essentially be plotted to one element only. It replicates pupil arranged education attentions on computing pupil presentation subsequently assembling to during their profession, with importance on four years of valediction.

Electrical & Electronics engineering and Computer science & engineering programs structures essential courses that cover essential engineering science and strategy parts to assistance student improvement in depth information of engineering principles. Pupils also have the chance to choose a variation of mechanical and open selective courses from core programs. Mini assignments, session, main project, engineering training and mechanical club arrangements will support them to exercise proficient supplement to education. Students are fortified to link, contribute and assistance to form symposiums, student paper competition and trade - organization relations. IE (EEE) student chapter, IEEE student branch and computing club is vigorous with EEE and student involvement.

Curriculum development process is a continuous process, primarily done by professors of public and private universities; it is bordered and permitted by Board of syndicate of Eastern University. The arrangement of the syllabus must deliver array transversely the range of engineering matters obscure through the label of the program. EEE and CSE curriculum is mainly planned founded on lead societies IEEE. So, the following course is introduced.

1.1 Fundamental of Statistics

Course planner of the course will deliver a lecture arrangement plus thorough plan for the semester, lessons and assessment arrangement. This will help to preserve steadiness of teaching learning procedure through the classes.

2. Program Educational Objective (PEO)

By defining vision and mission of the branches in link with the organization vision and mission through enchanting contribution from several stake receptacles such as teachers, upper administration, particular-forms, alumni, manufacturing and valediction students, the arrangement for outcome-based education begins. The definite mission and vision are permitted by the Department Curriculum Board confirming uniformity with the

vision and mission of the Institute. Program Educational Objectives (PEO) is founded on BAETE Graduate attributes and the current situation of Engineering (BAETE)(IEB). Every program is prearranged to brand students for constant education and effective professions in business, academia and investigation.

The curriculums are one of the core utensils to establish pupils in attaining PEOs. Therefore, the meaning of the courses in the program exact curriculum to PEO requirements to be measured in order to launch their level of maintenance to PEO. The achievement of the PEOs of the department confirmed by various organizational systems. Program Educational Objectives (PEOs) transmit to the career and professional doings of pupils after they graduate from the program. Thus, valuation and estimation of the purposes needs assessment utensils that can be beneficial after graduation. Though, keeping the implication of connection of the curriculum and the valuation opportunities such as task data and advanced education entrance presentation, these valuations are reserved as additional indication. Steadiness of the PEOs through the mission of the engineering branch is a significant alarm.

3. Course on Statistics

This segment explains the explanation of the course on Statistics measured for the talk. Statistics is a basic course that underline on fundamentals of probability and statistics.

Probability theory and statistics are today a very significant tools in manufacturing and engineering. Probability theory is ardent to the learning of ambiguity and changeability, which are important words also in industry, which proliferates with circumstances categorized by ambiguity about the significances of courses of action and by unpredictability of men, materials and machines.

Statistics can be labeled as the study of how to make inferences and judgments in the face of uncertainty and changeability: this is exactly the type of activity which is identical in manufacturing movement.

In modern industry it is most important to choose ways of action, which are optimum from an economic point of view. Both probability and statistics provide valuable tools for making such choices.

Mass production characterizes present day industry. Statistics furnishes methods for studying and monitoring production processes.

4. Program Outcomes

Sl #	Characteristics	Pos /ILOs / Graduate Attribute Profiles
	Engineering Knowledge:	PO1: Apply the knowledge of mathematics, science and engineering to solve the electrical & electronics engineering problems.
	Problem Analysis:	PO2: Identify, formulate and solve power & energy system problems.
	Design / development of solutions:	PO3: Design and conduct experiments on analog and digital electronic systems to analyze and interpret data.
	Investigation:	PO4: Apply the principles of electrical circuits and machines for testing and analysis
	Modern Tool Usage: P	PO5: Design power electronic systems and control systems as per needs and specifications
	The Engineer and Society	PO6: Model and simulate signals and systems, control systems and energy systems using modern engineering tools.
	Environment and Sustainability:	PO7: Practice professional ethics and engage in lifelong learning.
	Ethics:	PO8: Communicate effectively and work in a team using common tools to achieve project objectives.
	Individual and Teamwork:	PO9: Recognize professional and personal responsibility towards the community.
	Communication:	PO10: Level of communication according to type of activities performed
	Project Management and Finance:	PO11: Level of management required for differing types of activity
	Lifelong learning:	PO12: Preparation for and depth of continuing learning

(baetebangladesh) (ABET)(Washington Accord)

5. Learning Outcomes

CO1. Understand and apply the outcomes of statistical works.

CO2. Classify the suitable statistical process to investigate the data

CO3. Choose the suitable probability distributions to label real ecosystem circumstances.

CO delivery and assessment:

Table 1: CO delivery and assessment

Cos	Corresponding Pos	Bloom's Taxonomy domain/level (C: Cognitive, P: Psychomotor, A: Affective)	Delivery Methods and Activities	Assessment tools
CO1	PO1, PO2	C1, C2, C3, A1, P2	Lecture, Notes, Problem solution	Quiz, Assignment, Examination
CO2	PO1, PO2, PO3, PO4, PO5, PO9, PO11	C1, C2, C3, A1, P2	Lectures, Notes, Practice Problems	Quiz, Assignment, Examination
CO3	PO1, PO2, PO3, PO4, PO5, PO9, PO11,	C1, C2, C3, A1, P2	Lectures, Notes, Practice Problems	Quiz, Assignment, Examination

6. CO-PO Mapping (Theory course)

Table 2: CO PO mapping

CO/PO Mapping (PUT ✓ for every CO)												
COs	Program Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓	✓	✓	✓	✓				✓		✓	
CO3	✓	✓	✓	✓	✓				✓		✓	

7. Attainment of the POs

Dissimilar course conveyance methods such as providing lecture-sheets, power point presentations, quizzes, question and answering part lecture combined with discussion etc. are used to convey the course and measure the efficiency of these approaches for the attainment of the POs. Diagraming of course result with question paper assistances to measure the knowledge level, plan and analysis content. Table 1 gives delivery and assessment and Table 1 shows CO and PO mapping.

8. Sample Question Paper of Statistics

Course Code: STS 301, Course Title: Fundamentals of Statistics

Time: 2.0 Hours Total marks: 40																																											
NB:	Right margin indicates the full marks.																																										
	SECTION: A There are two questions in this section. Answer all of them.																																										
1. (a)	Find the value of q such that (a) $P(Z > q) = 0.2101$, (b) $P(q < Z < -0.12) = 0.5197$. from given standard normal distribution	[04]	CO2																																								
(b)	Write down relationship to the Normal and Standard normal distribution	[02]	CO1																																								
(c)	The mean time for an electronic component to fail is 100hours. Determine the probability of a component to survive more than 100 hours	[04]	CO2																																								
2.	From the given table <table border="1" style="margin: 10px auto; border-collapse: collapse; text-align: center;"> <thead> <tr> <th></th> <th>Y</th> <th colspan="4"></th> <th>Marginal X</th> </tr> <tr> <th></th> <th></th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th></th> </tr> </thead> <tbody> <tr> <th rowspan="3">X</th> <th>1</th> <td>0.02</td> <td>0.04</td> <td>0.06</td> <td>0.08</td> <td>0.2</td> </tr> <tr> <th>2</th> <td>0.03</td> <td>0.06</td> <td>0.09</td> <td>0.12</td> <td>0.3</td> </tr> <tr> <th>3</th> <td>0.05</td> <td>0.10</td> <td>0.15</td> <td>0.20</td> <td>0.5</td> </tr> <tr> <th colspan="2">Marginal Y</th> <td>0.10</td> <td>0.20</td> <td>0.30</td> <td>0.40</td> <td>1.0</td> </tr> </tbody> </table>		Y					Marginal X			1	2	3	4		X	1	0.02	0.04	0.06	0.08	0.2	2	0.03	0.06	0.09	0.12	0.3	3	0.05	0.10	0.15	0.20	0.5	Marginal Y		0.10	0.20	0.30	0.40	1.0	[03] [05] [02]	CO3
	Y					Marginal X																																					
		1	2	3	4																																						
X	1	0.02	0.04	0.06	0.08	0.2																																					
	2	0.03	0.06	0.09	0.12	0.3																																					
	3	0.05	0.10	0.15	0.20	0.5																																					
Marginal Y		0.10	0.20	0.30	0.40	1.0																																					
	Calculate the expected value of x and y. Calculate the variance of x and y. Find the correlation coefficient ρ ?																																										

	SECTION: B There are three questions in this section. Answer any two of them.																				
3. (a)	Let Y be a random, variable with the following probability distribution <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <tr> <td style="padding: 5px;">Y</td> <td style="padding: 5px;">-2</td> <td style="padding: 5px;">5</td> <td style="padding: 5px;">8</td> </tr> <tr> <td style="padding: 5px;">f(y)</td> <td style="padding: 5px;">1/5</td> <td style="padding: 5px;">1/3</td> <td style="padding: 5px;">1/4</td> </tr> </table> Find $\mu_{g(y)}$, where $g(y) = (2y+1)3$.	Y	-2	5	8	f(y)	1/5	1/3	1/4	[05]	CO2										
Y	-2	5	8																		
f(y)	1/5	1/3	1/4																		
(b)	The following table shows the marks obtained by 100 candidates in an examination. Calculate standard deviation. <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <tr> <td style="padding: 5px;">Class interval</td> <td style="padding: 5px;">0-4</td> <td style="padding: 5px;">4-8</td> <td style="padding: 5px;">8-12</td> <td style="padding: 5px;">12-16</td> </tr> <tr> <td style="padding: 5px;">Frequency</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">8</td> <td style="padding: 5px;">2</td> <td style="padding: 5px;">1</td> </tr> </table>	Class interval	0-4	4-8	8-12	12-16	Frequency	4	8	2	1	[05]	CO2								
Class interval	0-4	4-8	8-12	12-16																	
Frequency	4	8	2	1																	
4. (a)	A random sample of 200 automobile owners shows that, in Comilla, an automobile is driven on the average 93900 kilometers per year with a standard deviation of 9900 kilometres, Construct a 98% confidence interval for the average number of kilometers driven annually in Chittagong. What can we assert with 98% confidence about the possible size of our error if we estimate the average number of kilometers driven by car owners in Chittagong to be 43500 kilometers per year?	[05]	CO2																		
(b)	A soft drink machine at a steak house is regulated so that the amount of drink dispensed is approximately normally distributed with a mean of 200 millilitres and a standard deviation 15 millilitres. The machine is checked periodically by taking sample of 9 drinks and computing the average content. If x falls in the interval $191 < x < 209$, the machine is thought to be operating satisfactorily: otherwise we conclude that $\mu \neq 200$ millilitres. I) Find the probability of committing a type I error if when $\mu = 200$ millilitres. II) Find the probability of committing a type II error when $\mu = 215$ milliliters.	[05]	CO3																		
5.(a)	State Central limit theorem.	[02]	CO2																		
(b)	A set of 5 similar coins is tossed 320 times and the result is <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <tr> <td style="padding: 5px;">No. of heads</td> <td style="padding: 5px;">0</td> <td style="padding: 5px;">1</td> <td style="padding: 5px;">2</td> <td style="padding: 5px;">3</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">5</td> </tr> <tr> <td style="padding: 5px;">Frequency</td> <td style="padding: 5px;">6</td> <td style="padding: 5px;">27</td> <td style="padding: 5px;">72</td> <td style="padding: 5px;">112</td> <td style="padding: 5px;">71</td> <td style="padding: 5px;">32</td> </tr> </table> Test the hypothesis that the data follow a binomial distribution.	No. of heads	0	1	2	3	4	5	Frequency	6	27	72	112	71	32	[04]	CO3				
No. of heads	0	1	2	3	4	5															
Frequency	6	27	72	112	71	32															
(c)	Draw the line. Find the regression line of y on x for the following data: <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <tr> <td style="padding: 5px;">X</td> <td style="padding: 5px;">1</td> <td style="padding: 5px;">3</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">6</td> <td style="padding: 5px;">8</td> <td style="padding: 5px;">9</td> <td style="padding: 5px;">11</td> <td style="padding: 5px;">14</td> </tr> <tr> <td style="padding: 5px;">Y</td> <td style="padding: 5px;">1</td> <td style="padding: 5px;">2</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">5</td> <td style="padding: 5px;">7</td> <td style="padding: 5px;">8</td> <td style="padding: 5px;">9</td> </tr> </table> Estimate the value of y when $x = 10$.	X	1	3	4	6	8	9	11	14	Y	1	2	4	4	5	7	8	9	[04]	CO3
X	1	3	4	6	8	9	11	14													
Y	1	2	4	4	5	7	8	9													

9. List of Course Learning Outcomes

The program outcomes are assessed with the help of course outcomes of the relevant courses by result analysis. Processes are provided through direct examinations i.e. through end semester examination grades of the respective courses. End semester grade

returns continuous evaluation including Class Performance, Class tests i.e. quizzes, assignments and the mid and final examination of semester

Compile final exam grade marks for all pupils in all sections at the end of the semester. Course level PO attainment is attained, individual CO attainment is evaluated, PO attainment for associated POs addressed by the course is obtained based on set content target.

Program level PO attainment is designed based on all core courses PO attainment average of assessment is considered.

Actions to improve (if needed) PO attainment for the next semester is deliberate through improvement in course content delivery assessment methods during the annual Program review.

10. Performance Criteria Target

For assessment, pupils' achievement may be pre-defined any grade (may be a minimum of grade C) in the respective courses, course teacher and program coordinator will take decision. If the goal is achieved, then course teacher can go for better grade. If the percentage of CO-PO attainment is 40% or more taking the average of assessment, the PO is considered to be achieved. Again, the percentage can be increased.

The following given sample is for 40% CO-PO achievement.

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Grade sheet
 Course: STS 301 (Fundamentals of Statistics)

SL#.	ID	Name	Attd./ perform	Quiz (Best three)			TQ	Mid-Term			Total in Mid	Final			Total in Final	Total	Letter Grade	CO & PO ACHIEVEMENT ANALYSIS														
				CT1	CT2	Assign.		CO1	CO2	CO3		CO1	CO2	CO3				CO MARK OBTAINED			CO MARK IN PERCENTAGE			CO ACHIEVEMENT (>=40%)			PO ACHIEVEMENT (>=40%)					
																		CO1	CO2	CO3	CO1	CO2	CO3	CO1	CO2	CO3	CO1	CO2	CO3	PO1	PO2	PO3
																		10	10	10	20	8	3	29	30	4	23	23	40	#	5	20
1	ID1	N A M E	9.0	8.0	10.0	10.0	19.0	2	0.0	5.0	7.0	3.0	4.0	18.0	##	##	B	2.0	10.0	13.0	##	##	##	Y	Y	N	Y	Y	N			
2	ID2	N A M E	7.0	9.0	10.0	10.0	19.0	3	3.0	19.0	##	1.0	16.0	##	##	##	A+	3.0	13.0	28	##	##	##	Y	Y	Y	Y	Y	Y			
3	ID3	N A M E	8.0	3.0	0.0	10.0	9.0	1	2.0	4.0	7.0	0.0	18.0	12.5	##	##	C+	1.0	2.0	7.0	##	10.0	14.0	N	N	N	N	N	N			
4	ID4	N A M E	0.0	Abs	Abs	Abs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	F	0.0	Abs	Abs	0.0	Abs	Abs	N	Y	Y	N	Y	Y			
5	ID5	N A M E	6.0	0.0	0.0	0.0	0.0	0	0.0	9.0	9.0	3.5	16.0	17.0	##	51.5	C+	0.0	0.0	9.0	0.0	0.0	18.0	N	N	N	N	N	N			
6	ID6	N A M E	9.0	9.0	7.0	10.0	18.0	2	0.0	11.5	13.5	1.0	7.5	7.0	15.5	##	B-	2.0	7.0	##	##	##	41.0	Y	N	Y	Y	N	Y			
7	ID7	N A M E	8.0	10.0	7.5	10.0	19.0	3	3.0	17.0	##	1.0	##	18.0	##	##	A+	3.0	10.5	##	##	##	##	Y	Y	Y	Y	Y	Y			
8	ID8	N A M E	8.0	10.0	10.0	10.0	##	3	0.0	19.0	##	0.0	11.5	21.0	##	##	A+	3.0	10.0	##	##	##	##	Y	Y	Y	Y	Y	Y			

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9	ID 9	N A M E	8.0	8.0	10.0	10.0	19.0	4	0.0	13.0	17.0	1.0	13.0	21.5	##	##	A	4.0	10.0	21.0	##	##	##	Y	Y	Y	Y	Y	Y	
10	ID 10	N A M E	7.0	6.0	0.0	10.0	11.0	2	0.0	2.0	4.0	0.0	0.0	0.0	0.0	##	F	2.0	0.0	8.0	##	0.0	16.0	Y	N	N	Y	N	N	
11	ID 11	N A M E	7.0	9.0	6.0	10.0	17.0	2	0.0	13.0	15.0	0.0	8.0	6.0	14.0	##	C+	2.0	6.0	##	##	##	Y	N	Y	Y	N	Y		
12	ID 12	N A M E	8.5	5.0	0.0	10.0	10.0	2	0.0	4.5	6.5	0.0	0.0	0.0	0.0	##	F	2.0	0.0	9.5	##	0.0	19.0	Y	N	N	Y	N	N	
13	ID 13	N A M E	8.0	10.0	6.0	10.0	18.0	1	0.0	13.5	14.5	0.0	8.0	7.0	15.0	##	B-	1.0	6.0	##	##	##	N	N	Y	N	N	Y		
14	ID 14	N A M E	7.0	4.0	10.0	10.0	16.0	1	0.0	13.0	14.0	2.0	4.0	4.0	10.0	##	C	1.0	10.0	17.0	##	##	##	N	Y	N	N	Y	N	
15	ID 15	N A M E	7.0	8.0	10.0	10.0	19.0	3	0.0	13.0	16.0	1.0	7.5	21.0	##	71.5	A-	3.0	10.0	21.0	##	##	##	Y	Y	Y	Y	Y	Y	
Average			7.2	7.1	6.2	9.3	##	1.93	0.5	10.4	12.9	0.9	8.9	11.5	21.3	#	B-	0					YES	YES	YES	YES	YES	YES	YES	YES
																							###	###	###	###	###	###	###	

The table displays the amount of CO-PO achievement. Where the course valuation is not achieved the course coordinator along with corresponding teachers should choose upon the achievement strategies to progress the structure. In this particular study course end survey as well as course outcome question paper mapping is showing satisfactory attainment of CO's. In order to obtain continuous improvement, set target must be increased and analyze the assessment. The feedback from alumni and industry experts arise the need for the curriculum design with more industry institute interaction and simulation assisted study.

10. Conclusion

In the above sample assessment average result is C+, which is good, The CO-PO attained yes (Y) for 40% attainment. So, grade and percentage of CO PO may be increased for next semester. OBE helps a constant quality enhancement on the Program founded on steady assessment of the achievement of Cs and POs. POs are measured in overall with the outcome and COs are measured through a demanding process of question to CO achievement. This needs a lively part of course planner in determining real-world question design to attain the consequence. Course arranger grasps a great concern of scheming the course syllabus to setting up of question paper that can lenience the achievement examination procedure. All valuations to be applied in the subject (e.g., Assignment, Class Test, Project, Mid-term and Final Examination) should be organized earlier the commencement of the semester. This is achievable if the course organizer has adequate knowledge to design for. Constant development could be executed by focused on the subjects at hand. Though, dealing wide-ranging data is time overwhelming and deters the obligation of academic members towards operative OBE implementation. An Academic committee should progress a structure that affords standardized CO-PO fulfilment investigation. Finally, the success of OBE application goes back to the exercise of the concerned course planner and structural ability accessible

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