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COURSE OUTCOMES' PERFORMANCE IN STATISTICS FOR ENGINEERS

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ABSTRACT

The purpose of this study is to assess the level of knowledge and abilities of student based on ten course outcomes in Statistics for Engineers (MATB133). The course is a first year course in Bachelor of Civil Engineering, Universiti Tenaga Nasional. The assessment was conducted on ninety six students of semester 1, 2012/2013 through assignments, quizzes, test and final examination. The finding shows that the students' achievement is quite good in CO6, CO9 and CO10. However, the performance in another seven course outcome were not as expected. Hopefully, the result of analysis will help lecturers to improve the performance of future students. The paper also provides suggestions on course outcomes that need to be focused on and more attention.

Keywords: Course outcomes, Programme outcomes, Achievement, Assessment, MATB133.

1. INTRODUCTION

The engineering programme needs to prepare young engineers to practice in an increasingly complex workplace with changing and increasing demands of public and employers. Teaching and learning process in engineering programmes abided by the outcome based education (OBE) approach. The (OBE) approach offers many advantages as a way to achieve this. In OBE approach, the educational outcomes are clearly and unambiguously specified (Harden, 1999). OBE is a performance-based approach in curriculum development, offers a powerful way of improving and managing engineering education (Schalock, 2001). The implementation of OBE is to ensure

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the academic programme, the execution and delivery and assessment methods can produce engineering graduates who are competitive and skilled. This also will ensure the quality of engineering education attains the minimum standard comparable to global practice. In addition, by implementing OBE, the continuous quality improvement (CQI) can be done, especially in the coordination and improvement of the engineering programme which is also taken into account the role and needs of stakeholders and industries in the formulation of Programme Educational Objectives (PEO) and Programme Outcomes (PO) (Wan Hamidon, 2009).

As for that, College of Engineering, Universiti Tenaga Nasional (UNITEN) has an annual programme review (APR) to look into CQI in all engineering courses in order to meet accreditation and stakeholders' requirement. The emphasis is on the product - what kind of engineer will be produced - rather than on the educational process. In APR, the outcomes will determine the curriculum content and its organization, the courses offered, the teaching methods and strategies, the assessment process and the educational environment. The discussion is on PEO, PO followed by course outcomes (CO) of the courses. Coordinator of the course identified or improved the existing CO and PO based on what kind of engineer need to know and acquire. Each statement of CO shall be written clearly on evaluation methods and assessment criteria with an intention to determine the knowledge, skills and abilities of each student after completed the course. Assessment in OBE approach is a systematic and ongoing process of collecting, interpreting, and undertaking the information relating to the goals and outcomes developed to support the institution's purpose and mission.

The achievement of CO and PO depend on the performance of students in their tasks such as quizzes, tests, final examination, projects, assignments or other types of assessments where all this gives the impression of student achievement (Rozeha *et al.*, 2007). Assessment of each student for all tasks assigned in each course demonstrated the achievement of the CO. Through this CO achievement, the improvement on the course can be done, especially in terms of teaching, learning, and assessment methods. Therefore, this study aims to assess the level of knowledge, skills and abilities of student based on the CO and PO in the first year course of Bachelor of Civil Engineering, Statistics for Engineers. The study was conducted as one of initiative to improve the teaching and learning process in this particular course.

2. STATISTICS FOR ENGINEERS COURSE

Statistics for Engineers (MATB133) is one of the first year course in Bachelor of Civil Engineering programme in UNITEN. The course is offered in Semester 1 and Semester 2 every year. This course introduces basic probability, continuous and discrete random variables, distribution functions and their applications, relationship between distributions, fundamental sampling distribution, sample estimation and hypothesis testing, and simple linear regression and correlation. The objective of the paper is to present the level of knowledge, skills and abilities of student based on the CO and PO of MATB133, semester 1, 2012/2013. The achievement of CO and PO is based on the performance of MATB133 students in final examination, test, quizzes and

assignments assigned throughout the semester. The PO set by college contains twelve outcomes as listed in Table 1 in such a way MATB133 contribute in PO1 and PO2 only since it is a first year course.

Table- 1. Twelve Programme Outcomes

	Programme Outcomes
1.	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specializations to the solution of complex engineering problems
2.	Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences
3.	Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations
4.	Conduct investigation into complex problems using research- based knowledge and research methods, including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions
5.	Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations
6.	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice;
7.	Understand the impact of professional engineering solutions to societal and environmental contexts and demonstrate knowledge of and need for sustainable development
8.	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice
9.	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clearance
10.	Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings
11.	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change
12.	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

Source: (Engineering Programme Accreditation Manual, 2012)

Meanwhile, CO contains 10 outcomes need to be acquired by students at the end of the semester. Table 2 shows the outcomes of MATB133 and the related PO to CO. Table 2 includes the level of Bloom Taxonomy, and method of delivery and assessment. The students have been acknowledged on the CO, method of delivery and assessment at the beginning of the semester. The

assessment in MATB133 was based on Bloom's Level of Cognitive Domain as presented by Huitt (2011) in order to assess the knowledge and development of intellectual skills. There is six Bloom's Levels of Cognitive Domain (Huitt, 2011), that the knowledge (LCD1), comprehension (LCD2), application (LCD3), analysis (LCD4), synthesis (LCD5) and evaluation (LCD6). The course comprises three Bloom's Levels of Cognitive Domains that are LCD2, LCD3 and LCD4.

Table-2. Ten Course Outcomes of MATB133 – Statistics For Engineers for Sem 1, 2012/2013

CO	Course Outcomes	PO	Bloom's Level of Cognitive Domain	Method Of Delivery	Method of Assessment
CO1	Understand and describe sample spaces and events for random experiments. Interpret and calculate probabilities of events in discrete sample spaces, and conditional probabilities of events using Bayes' theorem.	PO1	LCD2	Lecture, Classroom discussions, Independent Literature & Tutorials	Assignment, quiz, test and final exam
CO2	Use probability as a tool to develop probability distribution that serve as models for any random variables	PO2	LCD3	Lecture, Classroom discussions, Independent Literature & Tutorials	Assignment, quiz, test and final exam
CO3	Distinguish any discrete distribution from continuous probability distributions. Apply these models in different physical situations.	PO2	LCD4	Lecture, Classroom discussions, Independent Literature & Tutorials	Assignment, quiz, test and final exam
CO4	Understand the concept of a probability distribution and real-world problems involving various distributions, including binomial, geometric, hypergeometric, and Poisson distributions and apply it to solve the real-world problem.	PO1	LCD3	Lecture, Classroom discussions, Independent Literature & Tutorials	Assignment, quiz, test and final exam
CO5	Identify continuous probability distribution, Normal distribution. Apply these models in different physical situations.	PO2	LCD2	Lecture, Classroom discussions, Independent Literature & Tutorials	Assignment, quiz and final exam
CO6	Construct interval estimation of the mean in making inferences about a population.	PO2	LCD2	Lecture, Classroom discussions, Independent Literature & Tutorials	Assignment, quiz and final exam
CO7	Perform a significant test of hypothesis concerning the values of population mean based on	PO1	LCD4	Lecture, Classroom discussions, Independent	Assignment, quiz and final exam

CO	Course Outcomes	PO	Bloom's Level of Cognitive Domain	Method Of Delivery	Method of Assessment
	Normal distribution.			Literature & Tutorials	
CO8	Perform a significant test of hypothesis concerning the values of population mean based on t - distribution.	PO1	LCD4	Lecture, Classroom discussions, Independent Literature & Tutorials	Assignment, quiz and final exam
CO9	Predict the value of any independent variable to the value of dependent variable using a linear regression analysis.	PO2	LCD4	Lecture, Classroom discussions, Independent Literature & Tutorials	Quiz and final exam
CO10	Measure and analyse the strength of the relationship between 2 variables using a correlation analysis.	PO2	LCD4	Lecture, Classroom discussions, Independent Literature & Tutorials	Quiz and final exam

3. METHODOLOGY

The study was done by analysing all scoring information from assignments, quizzes, tests and final exam that contributes to the achievement of CO. There were 100 students taking the course in session 2012/2013. The number of students divided into three groups: excellent, moderate and weak, referring to the students in the class based on their total mark. The students in one third highest mark meaning with the first 32 position is in group 'excellent'; position 33th till 65th in group 'moderate', and 'weak' students are in the position 66th to 96th.

The achievement of each CO, performed by students has been analysed using average and percentage. The average scores of CO for each group of students is analysed to ensure that the strengths of each student and identify CO that does not have a good track for all groups. To obtain the achievement of CO by each student, each mark contributes to a CO are aggregated and divided by total full marks CO, and then multiplied by 100 to get its percentage. The average of this score for all students represents the achievement of CO. The calculation for CO achievement present by the following equation.

$$CO_i \ Achievement = Average\left[\frac{\sum_{i=1}^{n} SO_i}{Total\ score\ of\ O_i} \times 100\right]$$

Where CO – Course outcomes; SO - student's score for $CO_{i;}$ O_i - Course outcome

4. ACHIEVEMENT OF CO, IN MATB133

The finding of the study, the average of ten course outcomes for three groups and overall presented in Table 3 and Figure 1. The study also looks into percentage of students obtained above and below 55% of each CO. UNITEN has set 55% as a minimum score for grade C, where the student may retake the course if they obtained grade C- and below. The students who fail the course are compulsory to repeat the course.

Table-3. Achievement of CO

Course Outcomes	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8	CO9&CO10
Excellent	95.3	80.6	53.3	84.8	83.1	94.0	69.8	55.2	90.3
Moderate	85.9	55.1	19.6	78.3	64.3	90.6	50.6	34.6	86.0
Weak	77.4	40.8	5.0	68.5	60.5	86.3	28.8	18.5	77.3
Overall	86.2	58.9	*26.0*	77.2	69.3	90.3	*49.7*	*36.1*	84.5
CO score > 50%	90.6	58.3	14.6	91.7	69.8	100.0	45.8	22.9	93.8
CO score < 50%	9.4	41.7	85.4	8.3	30.2	0.0	54.2	77.1	6.3

Table 3 shows that three highest scores for excellent group are CO1 (95.3%), CO6 (94%) and CO9 & CO10 (90.3%). Meanwhile, moderate group obtained three highest scores in CO6 (90.6%), CO9 & CO10 (86%) and CO1 (85.9%). The weakest group obtained CO6 (86.3%), CO1 (77.4%) and CO9 & CO10 (77.3%) as their three highest scores. The overall result shows that CO6 (90.3%), CO1 (86.2%) and CO9 & CO10 (84.5%) have been achieved more than 80% by the student. The CO1 and CO6 are two easiest topics in MATB133 and it was expected to have a very good score. However, CO9 & CO10 are an unexpected topic to be performed well by students, and the topic was taught two weeks before final exam.

Figure 1 shows the comparison among three groups according to their abilities: Excellent, Moderate and Weak. The students with moderate and weak group did not achieve a minimum requirement (55%) for CO3, CO7 and CO8, and the excellent group did not achieve 55% in CO3. The excellent group shows their best achievement in all COs except the lowest one, CO3 (53.3%). The moderate and weak group shows that they performed well in CO1, CO6 and CO9&CO10. In fact, all three groups have their three highest achievements in CO1, CO6 and CO9&CO10. Surprisingly, all three groups show lower achievement in CO3 and CO8 than the other CO achievement. Perhaps, this is caused by the level of difficulties of assessment for CO3 and CO8 in LCD4, where the students need to distinguish between two types of random variable before they proceed to solve probability problems in CO3. Meanwhile, in CO8, the students also need to distinguish between normal *z*-distribution and *t*-distribution before they can proceed to solve the related problem. This shows that the students have a problem to identify the real world problem into what type of random variable in CO3 and distribution in CO8.

Figure-1. CO's Achievements By Three Different Groups.

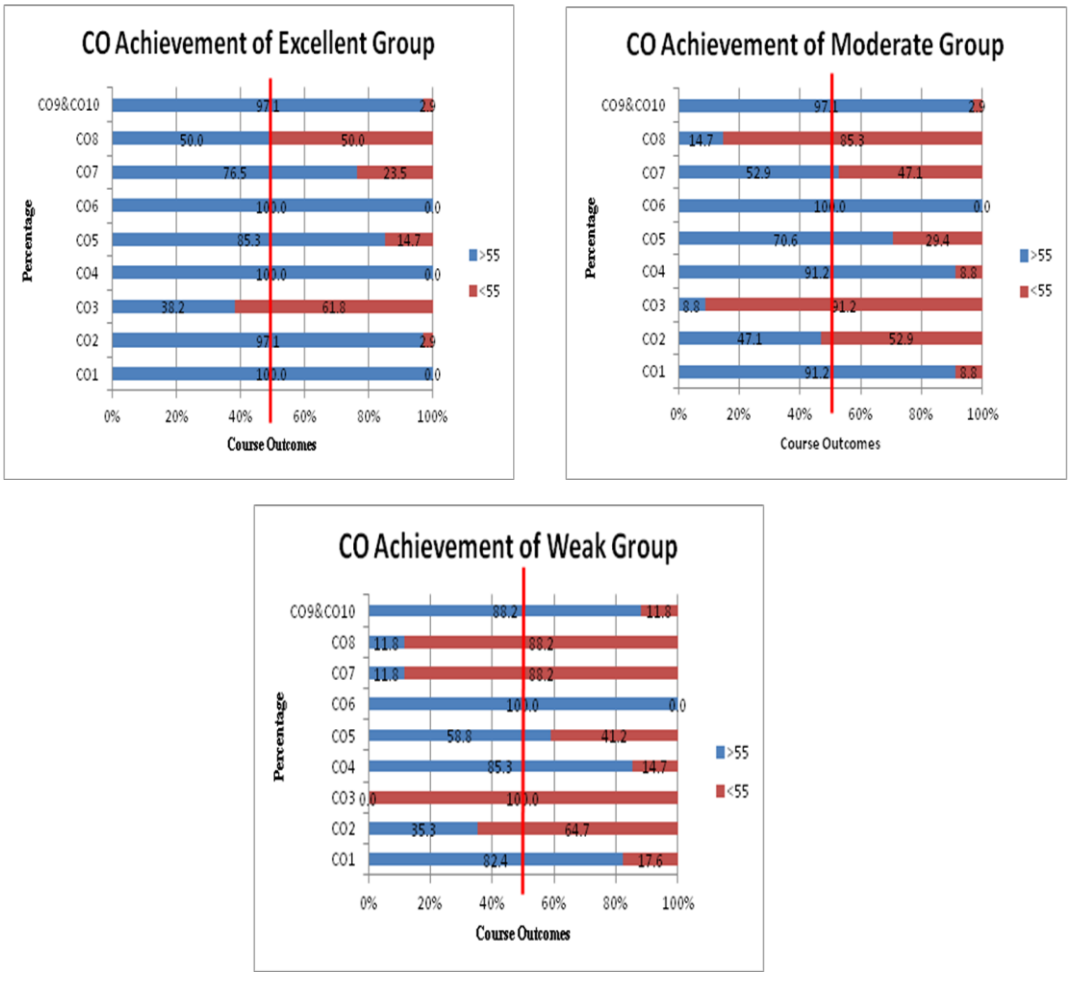
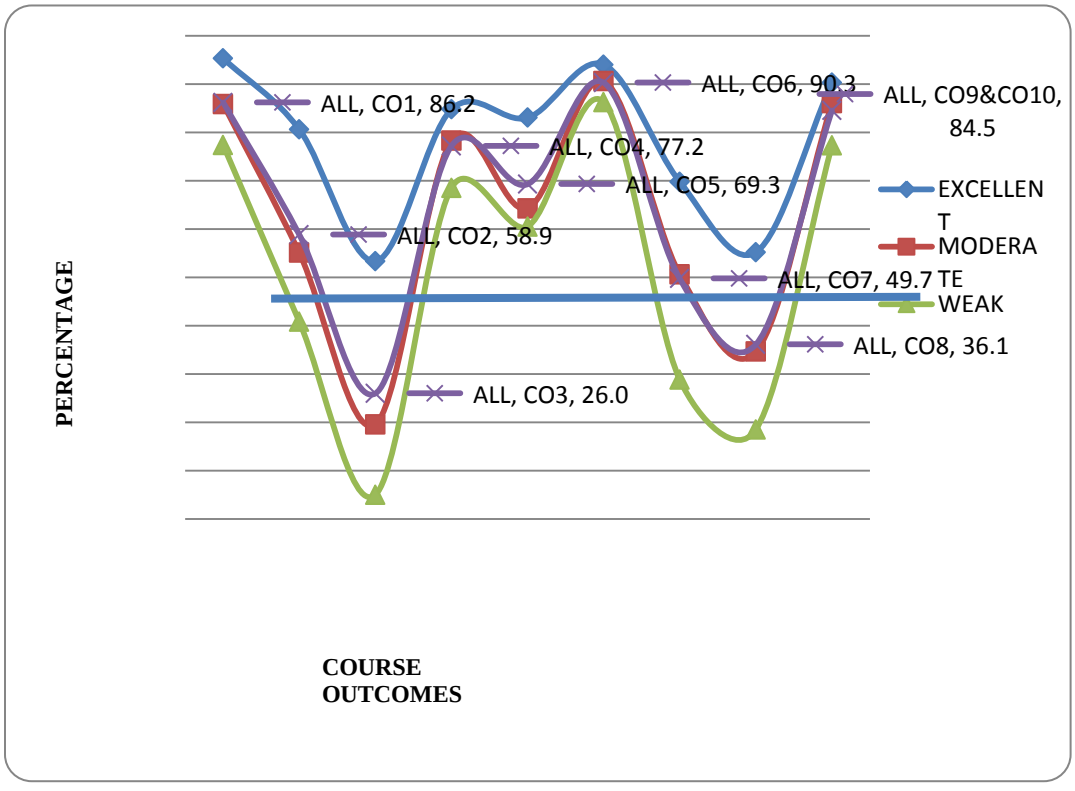


Figure 2 shows that the similar trend of achievement of CO for all three groups. The overall performance of students in CO achievement is close to achievement obtained by moderate group. It indicates that the students did not achieve a minimum requirement (55%) in CO3 (26%), CO7 (49.7%) and CO8 (36.1%). The students with weak abilities seem to have difficulties in all CO except CO6, which is constructed interval estimation of the men in making inferences about a population, i.e. Find the mean and standard deviation. However, they performed quite well in CO9&CO10, which are constructed linear regression line and find the correlation. Both formulae are provided in the final examination. The other two groups performed well, except CO3 and CO8.

Figure-2. Achievements of CO



5. CONCLUSION

The studies on achievements COs' for the course Statistics for Engineers (MATB133), a first year course in Bachelor of civil engineering, Universiti Tenaga Nasional, using the marks of assignments, quizzes, test and final examination. The CO1 and CO6 have the best performance, in which the results are expected because the Bloom's Level of Cognitive Domain for these two COs assessments are at LCD2. Though CO9 and CO10 also having assessment at LCD4, the topics are on linear regression and correlation, which are interrelated and easy to understand. Achievement of the other six COs: CO1, CO4, CO5, CO6, CO9 and CO10 are good since their average scores and the number of students who pass a relatively higher than 55%. CO3 has the lowest average scores compared to the CO where none of the student achieves 55% and above. However, improvement should also be taken by the lecturers such as emphasis on weak topics to overcome poor achievement.

It is suggested for lecturers to focus more on CO3, CO7 and CO8. It is important for lecturers make a greater effort to increase student understanding in the related topics. Lecturers are also urged to employ a different approach in delivering the related topics that might help improving the achievement on these three COs. More assignments need to be given after the lecture class to enhance students' understanding of the related topics. Among other improvements that could be done are: more exercises in the classroom and more frequent short quizzes in order to raise awareness, and give out more group works to get students study in groups. A great effort need to be made to the topics related to CO3, CO7 and CO8 in enhancing students' understanding of the

probability of random variable in real world problems. It can be done by having a study case that can relate exercise problems to the real world problems.

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