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Engineering Mathematics I: A Case Study of First Year Students at Faculty of Engineering, UNIMAS

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Abstract

The subject of mathematics is important as a prerequisite and requirement as most topics in engineering courses widely employ these fundamentals. The paper will describe an analysis based on Engineering Mathematics I course results for first year student of Semester I 2009/2010 academic year at the Faculty of Engineering at University of Malaysia Sarawak(UNIMAS). The aim is to identify the topics within Engineering Mathematics I, which may cause some difficulties for new students to understand. The performance that directly related to the students' weaknesses is obtained from the continuous assessments of the course, end of semester report analysis based on course outcomes and item analysis. The results will be used as the basis for improving the teaching and learning process for this course.

Keywords: engineering mathematics, first year, course outcome, item analysis

1. Introduction

Engineering Mathematics has always been the fundamental and essential components for engineering courses. This is because mathematical skills are required and necessary for the understanding of almost every conventional engineering subject [1]. At Faculty of Engineering UNIMAS, students have to undertake four engineering mathematics courses during their undergraduate study. The four courses are Engineering Mathematics I, Engineering Mathematics II, Engineering Mathematics III and Numerical Methods and Statistics. All the courses are three credits hour course and it is core courses.

Engineering Mathematics I is offered to first year student in Faculty of Engineering in the first semester of the first year of the programme. Each Engineering Mathematics course is a pre-requisite to the next mathematics course. Students must pass in order to be able to carry out the next Engineering Mathematics course.

The course syllabus cover topics of Function, Limit, Differentiation, Integration, Application of Differentiation, Application of Differentiation, Application of Integration, Sequence and Series, Complex Number. The course syllabus and course plan was designed as such to achieve four course outcomes (COs). The course outcomes are:

CO1 Ability to apply the fundamental concepts of calculus
CO2 Ability to solve trigonometric, functions and limits
CO3 Ability to formulate and apply differentiation and integration equations
CO4 Ability to solve series and complex number

The course outcome is designed to reflect the course content. It is then important to evaluate the outcome as to see whether the students achieve the course outcomes.

This paper is to discover topics in Engineering Mathematics I where the first year students perform well or otherwise. The course assessment includes mid-semester test, course works and final examination. The sub-components of course works mostly based on assignment, project or case study. The mark distribution is 30% for mid-semester test, 20% for course work and 50% for final examination. The discussed results here will be solely based on assessments of final examination result. The finding will lead to suggestions of how to overcome the weaknesses.

The objectives of this paper are;

i) To identify achievements of course outcomes of Engineering Mathematics I.
ii) To determine index of difficulty and discrimination from item analysis of

Engineering Mathematics I final examination questions.

iii) To suggest areas of improvement of teaching and learning process for Engineering Mathematics I.

2. Methodology

In this study, two analysis was carried out which are course outcomes achievement analysis and item analysis. The data of students score used in this analysis is based on final examination result only.

2.1. Data Collection

This study is based on a first year group of students on a degree programme in engineering. The group constituted of 298 registered students from four different engineering programmes which are Electronics, Mechanical, Civil and Chemical Engineering.

Data collected for this analysis is from final examination marks only which contribute 50% of the final result. The examinations for Engineering Mathematics are 3 hours where the students have to answer 5 questions. Each of the question will assessed different course outcomes or different topics. The questions have gone through qualitative analysis during examination vetting done by a group of expert in this area.

Table 1 shows the questions of which course outcomes is assessed. Notice that two questions were posed in order to assessed CO3. This question is to test on integration and differentiation topic.

Table 1. Mapping of Question No with COs

Question No.	Course Outcomes Assessed
1	CO1
2	CO2
3, 4	CO3
5	CO4

2.2 Course Outcomes

Course outcomes achievement is identify through end semester report analysis of final examination Engineering Mathematics I. It is measured based on percentage of marks of each question of final examination which is tabulated in Table 2. Table 2 is adopted in Faculty of Engineering in order to check the achievement of course outcomes. CO is achieved if >50% of students scored on the questions.

Table 2. Level and range of Course Outcomes Achievement

Strongly Not Achieved	< 25%
Not Achieved	25%-49%
Achieved	50%-74%
Strongly Achieved	≤ 75%

2.3. Method in Item Analysis

The question posed in the final examinations will also analyzed to check the appropriateness. This is acomplished by means of performing Difficulty index (p) and Discrimination index (D) analysis. The Difficulty index is defined as the proportion (%) of students who get a question right where p ranged from 0 to 1. When P is multiplied by 100, it ranges from 0% (for a very difficult item) to 100% (for a very easy one) [2].

Difficulty Index (p) equation is defined as in Eq. 1:

$$P = (\sum_{U} + \sum_{L}) / (2N(Score_{\max})) \quad (1)$$

Where,

$\sum_{U}$ = sum of scores for upper 25%-35%

$\sum_{L}$ = sum of scores for upper 25%-35%

N = 25 %-35% of number tested

$Score_{\max}$ =highest possible score on the question

The Discrimination index is defined as the difference in proportions of students who get an item right in two selected criterion group of examinees. Normally, when items being develop, the aim is to have the items to be sensitive to differences among individuals on the attribute range. D values ranges from -1.0 to +1.0. Generally, a positive discrimination suggest that the item is discriminating between the criterion groups in the direction as desired by the item developer.
The equation for Discrimination index (D) is defined in Eq.2:

(2)

The analysis was performed by taking 30% of high score and 30% of lower score group. Each of the questions is analyzed using Difficulty index (p) and Discrimination index (D).

The results will follow the classification from Reference [3]. It classifies item difficulty as "easy" if the index is .85 or above; "moderate" if it is between .51 and .84; and "hard" if it is .50 or below. It classifies item discrimination as "good" if the index is above .30; "fair" if it is between .10 and .30; and "poor" if it is below .10.

3. Results and discussion

This section will elaborate results of the analysis of course outcomes and item analysis.

3.1. Course Outcomes Achievement

Fig. 1 illustrates the course outcomes achievement based on final examination only. Overall, CO4 is the ***strongly achieved*** outcomes with 132 students out of 298 achieved it. This is followed by CO3 with 164 ***achieved*** the CO. The ***strongly not achieved*** and ***not achieved*** outcome is both from CO2 with 67 and 111 students' respectively.

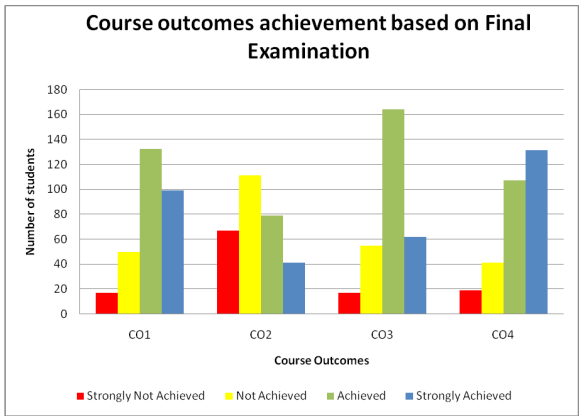

Fig. 1. Course Outcomes achievement based on final examination.

To illustrate this further, Table 3 grouped the course outcomes achievement into just 2 categories which is achieved and not achieved. It shows that CO2 significantly is not achieved compared to other CO. More than 60% of the students did not manage to achieve CO2.

Table 3. Percentage of course outcomes achieved and not achieved

This analysis revealed that CO2 is not achieved due to poor student performance in answering question no.2 (as mapped in Table 1).

3.2. Item Analysis

Item analysis is to determine index of difficulty and discrimination of the final examination question of Engineering Mathematics I. Item difficulty will provide an idea of how difficult is the final examination questions. Item discrimination is also to measure how well the questions able to separate between high score and low score student.

Table 4. shows the item difficulty and item discrimination for all of the questions posed to students during final examination. The results proved that there are balance and moderate set of questions for the final examinations.

Table 4. Item analysis for questions

Index/ Question No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Discrimination, D	0.29	0.39	0.23	0.36	0.31
Difficulty, P	0.66	0.47	0.79	0.46	0.68

For the purpose of this study, questions with non-achieved CO and strongly achieved will be discussed. Focusing on question no.2, the discrimination index of 0.39 revealed that question no.2 has good discrimination. Thus, CO2 is not achievable is unrelated with question design being too difficult, but because there are high number of students whom are weak in the assessed topic. Question no.2 is assessing student to solve limits problem.

Focusing on question no.5 (CO4), results in Table 4 proved question is moderate with good discrimination similar to question no.2. Question no.5 deals with series and complex number. More students are actually competent or having no problem in this topics.

As mentioned earlier, this study is based on final examination only. If the course work and mid-semester test are being included in the analysis, all course outcomes are probably accomplished.

4. Conclusion

Based on final examination results analysis, it shows that three out of four COs was achieved. CO2 are the strongly not achieved CO.

Index of difficulty and discrimination proved questions posed in Engineering Mathematics I final examination are balance question with difficulty ranging from 0.47 to 0.79 while discriminate well between high score and low score students.

It is discovered that limits are the most difficult topic for students of Engineering Mathematics I whereas series and complex number is the easiest or most students are competent with. Hence, limits topic should be given more emphasize during lecture. More tutorial or assignments on this area is suggested to build up better understanding on solving this problem. Furthermore, it is also recommended that more time allocated on limits topic. Further study to investigate the effectiveness of the action taken will be carried out.

It is tempting to extend the study to investigate the course outcomes achievement and item analysis based on mid-semester test as well to further confirm this paper outcome.

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