

ITEM ANALYSIS FOR FINAL EXAM QUESTIONS OF ENGINEERING MATHEMATICS COURSE (VECTOR CALCULUS) IN UKM

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Abstract

Evaluation of course outcome is one of the important elements in assessing students' performance in higher institutions. Most of the courses depend on examination result as a medium to evaluate the level of students' performances. In this study, the final exam questions of Vector Calculus course KKKQ1123 is being used to assess the difficulty index and discrimination index. 80 students from Department of Mechanical and Materials (JKMB) were involved in this study. This study found that the range of difficulty index is between 0.2 and 0.8, where the question that was categorized as difficult is question number 6 whereas for easy questions is question number 3. Meanwhile the range obtained for discrimination index was in the acceptable range, that is, between 0.2 and 0.6 which indicates that the exam questions are good. With this study, it is hope that it will guide the lecturers in constructing and crafting a good and reliable exam questions consistent with the level of student's ability.

Keywords: Difficulty index, Discrimination index, Final exam, Course outcome.

1. Introduction

Examinations and tests are two important elements in teaching and learning process for assessing students' performance at the end of each learning session [1]. The level of excellence and performance of the students in higher learning institutes are normally depending on the marks that they obtained from examination result in every course that they have taken. However, the result

obtained by the student does not give an accurate description on the overall level of excellence and performance of that student. Type of questions, level of difficulties of the questions as well as the ability of the students to answer the questions are among the main factors that influenced the examination result of the students. For lectures, they are also having a strong resistance in order to set up good and valid examination questions. Questions that are too difficult tend to lead to frustration and lead to deflated scores while questions that are too easy facilitate a decline in motivation and lead to inflated scores [2]. The quality of the examination questions can be improved by maintaining and developing sets of valid items so that future questions can be constructed and that cover a reasonable range of difficulty levels.

Item analysis is a tool that can help to improve test items and identify biased and unfair items [2]. Based on Othman et al. [3], analysis on exam questions can be used as a tool to indicate on how well the examination is constructed and the result will provide useful information about student's ability. Difficulty index and discrimination index are two methods in item analysis that can be used to assess the quality of the examination question. According to [4], item analysis can provide useful information in order to construct a good examination question. Difficulty index may be defined as the proportion of the students that answered the question correctly [5]. Wilson [6] has stated that difficulty index is the most essential component of item analysis. It has been used to identify level difficulty of a question that has been tested. Sarina et al. [7], has studied and discussed the method in determining the level of difficulty for every question that has been tested in an examination. They used the level of difficulty to determine whether the questions are easy, moderate or difficult. By determining the level of difficulty of each question that has been tested during the examination especially in final examination, the lecturer can identify how far will the course outcomes suffice and how far the questions be adequate to the level of understanding of each student towards the course outcomes. Suhaila et al. [8] stated that the result from the difficulty index can be used as a guide in enhancing teaching method as well as the course outcomes.

Difficulty index is not the only way to evaluate test items. In addition to difficulty index, discrimination index is also an important method in evaluating test items. Discrimination index can be described as a method that can determine whether the students who did well on the entire questions will also did well in particular question. This will provide information on how effectively the questions in the examination discriminate between students who are higher in ability measured and those who are low. Presence and absence of faults logically affects the values of discrimination [9]. Questions that discriminate poorly should be inspected for possible deficiencies [9-12]. Through both indices, the quality of future examination questions can be improved and the performance of the students can be well evaluated.

2. Methodology

2.1. Data

In general, the final examination result are used in order to measure performance of students including Engineering Mathematic courses in Faculty of Engineering

and Built Environment (FKAB), Universiti Kebangsaan Malaysia (UKM). Data were collected from final exam questions of first year students who undertake Engineering Mathematics I KKKQ1123 (Vector Calculus). Vector Calculus is a core subject for all four different departments in FKAB namely Department of Civil and Structural Engineering (JKAS), Department of Mechanical and Materials (JKMB), Department of Chemical and Process (JKKP) and Department of Electric Electronic and System (JKEES). For the purpose of this study, only 80 students from JKMB involved.

The final exam consists of two parts, which are Part A and Part B where students are required to answer all questions in Part A, while Part B is an optional question. However, only Part A of the exam question consists of 6 questions are considered. Covering most of the learning topics in KKKQ1123 such as vector functions, motion on a curve, partial derivative, double integral in polar coordinates, and etc., these instrument is assumed fit to measure the learning outcome of the subject (refer to Table 1).

Table 2 shows the course outcome that are assessed in Part A final exam paper for Vector Calculus KKKQ1123. Only CO5 is not being assessed in Part A. CO5 which is able to apply Green's Theorem, Stokes' Theorem and Gauss' Theorem in solving engineering problems are being assessed in Part B.

Table 1. Course outcome (CO) for vector calculus.

CO	Description
CO1	Understand the basic of surfaces in space.
CO2	Able to apply the basic concepts of partial derivatives.
CO3	Understand and able to apply the concepts of vector function, vector field, scalar field, gradient, divergence and curl.
CO4	Able to apply the concepts of line integral, double integral and triple integral in solving engineering problems.
CO5	Able to apply Green's Theorem, Stokes' Theorem and Gauss' Theorem in solving engineering problems.
CO6	Understanding basic concepts of differentiation and integration of complex function.

Table 2. Course outcomes that are achievable from the final exam questions for Vector Calculus course.

Question Number	Course Outcome					
	CO1	CO2	CO3	CO4	CO5	CO6
Q1			X			
Q2			X			
Q3		X				
Q4			X			
Q5	X			X		
Q6						X

2.2. Item analysis

Item analysis helps to determine the effectiveness of exam questions with respect to students' answer. The main purpose of item analysis is to improve exam questions by revising, reconstructing or eliminating ineffective items. Two main important instruments in item analysis are difficulty index and discrimination index. The results of the students' answer in the final exam question were used to analyze these two instruments.

2.2.1. Difficulty index

Difficulty index is an instrument to measure the difficulty level in examination question to classify the level of the question either easy, moderate or hard [12]. The value of difficulty index in the range between 0 and 1 [13]. The smaller the value of difficulty index, the more difficult the question and vice versa. The acceptable difficulty index is between 0.3 and 0.8 which is classified as a good question [14]. The classification of difficulty index are shown in Fig. 1. The formula for difficulty index is as follows:

$$\text{Difficulty Index}_{\text{question}(i)} = \frac{M_{T(i)} + M_{R(i)}}{N * m_i} \quad (1)$$

where

$M_{T(i)}$ = sum of marks for higher achievement student

$M_{R(i)}$ = sum of marks for lower achievement student

N = number of student in both group

m_i = total mark of question i

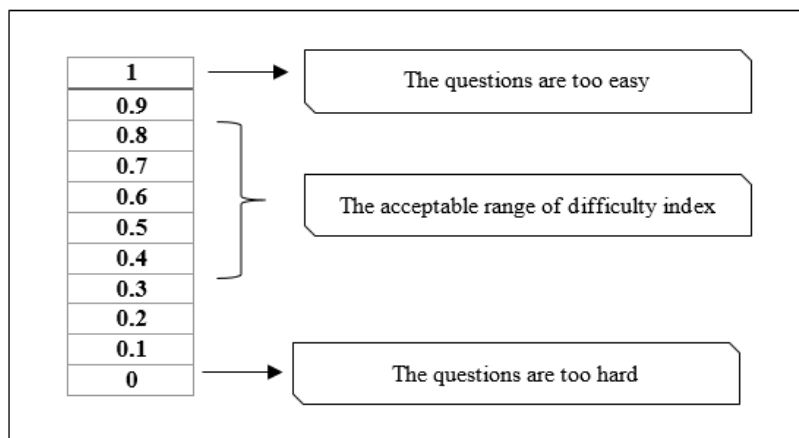


Fig. 1. Classification of difficulty index.

2.2.2. Discrimination index

Discrimination Index is an instrument to measure the difference in item difficulty between groups of student with high and low marks. The index varies between -1

to 1 where the item should have a positive discrimination index of at least 0.2 which are considered as a good item. If the item equals to 0, it means that there is no discrimination. However, the item with negative indices need to be revised (refer Fig. 2). The discrimination index is defined as follows:

$$\text{Discrimination Index}_{\text{question}(i)} = \frac{M_{T(i)} - M_{R(i)}}{N_T * m_i} \quad (2)$$

where

$M_{T(i)}$ = sum of marks for higher achievement student

$M_{R(i)}$ = sum of marks for lower achievement student

N_T = number of student in higher achievement group

m_i = total mark of question i

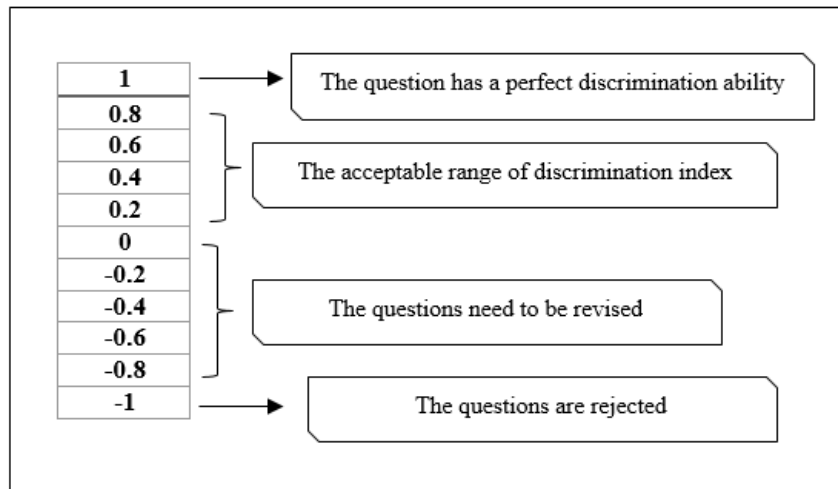


Fig. 2. Classification of discrimination index.

3. Result and Discussion

Figure 3 shows final examination result for Vector Calculus KKKQ1123. Out of 80 students from JKMB, only three students obtained A (range between 80-100 marks), while 26 students obtained E (range between 0-34 marks).

From this analysis, students' achievement can be divided into three groups namely higher, moderate and lower achievement students:

- (i) higher achievement group – 26 students
- (ii) moderate achievement group – 28 students
- (iii) lower achievement group – 26 students

The selection of these groups are based on lecturers' consideration. For example, the student who obtained less than 35% are grouped as lower achievement group. The number of student in higher achievement group must be equal to lower achievement group.

Based on the student result, the difficulty index for Part A of final examination KKKQ1123 was calculated as shown in Fig. 4. It is observed that the value of difficulty index is in the range of 0.2 and 0.8. From the figure, question 3 which are related to basic concept of partial derivative (CO2) the easiest question meanwhile the hardest questions is question number 6 (CO6).

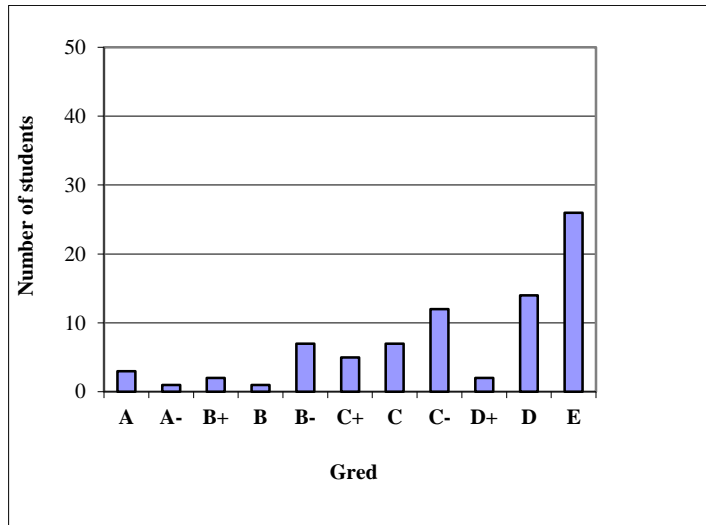


Fig. 3. Analysis of the final examination for Vector Calculus course.

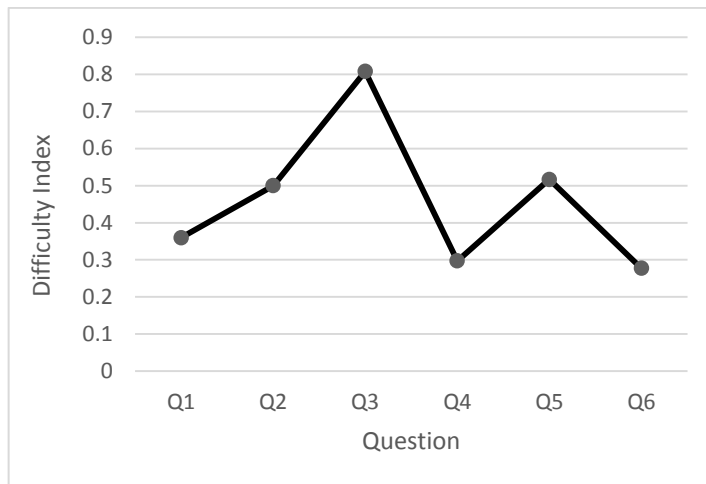


Fig. 4. Difficulty index for all the questions in Part A of Calculus Vector final examination.

Figure 5 shows the discrimination index for Part A of final examination KKKQ1123. The index varies between the range of 0.2 and 0.6. It indicates that the exam questions is good since it fall in the acceptable range

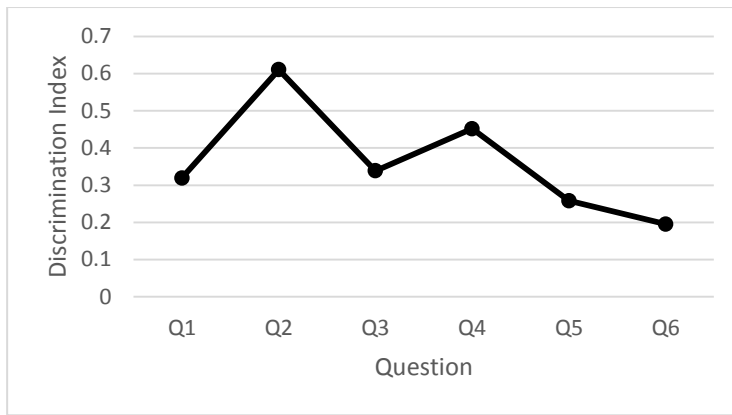


Fig. 5. Discrimination Index for all the questions in Part A of Calculus Vector final examination.

4. Conclusion

Item Analysis is a fundamental technique used to produce high quality exam questions. It provides information about student responses to each item test whether the item is acceptable or not, the level of difficulty of the items, and the power of discrimination between high achievement group and low achievement group. As for difficulty index, there are two questions which are question number 3 and 6 that needs to be revised in order to reduce the difficulty gap between the questions. In measuring the course outcome for the students, it is found that the course outcome, CO6 are not fulfil. Students were not able to apply the basic concepts of differentiation and integration of complex function.

It is also found that the discrimination indices have a positive values which indicates that high achievement group have a high probability of answering correctly and low achievement group have low probability of answering correctly. Overall, based on the result obtained, the quality of exam questions are considered as quite good.

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References

1. Jandaghi, G.; and Shaterian. F. (2008). Validity, reliability and difficulty indices for Instructor-Built exam questions. *Journal of Applied Quantitative Methods*, 3(2), 151-155.

2. Eaves, S.; and Erford, B. (2009). Item Analysis. Retrieved November 10, 2015, from <http://www.education.com/reference/article/item-analysis/>
3. Othman, H.; Ismail, N.A.; Asshaari, I.; Hamzah, F.M.; and Nopiah, Z.M. (2015). Application of Rasch measurement model for reliability measurement instrument in Vector Calculus course. *Journal of Engineering Science and Technology, Special Issue on UKM Teaching and Learning Congress 2013*, 77-83.
4. Othman, H.; Asshaari, I.; Bahaludin, H.; Tawil, N.M.; and Ismail, N.A. (2012). Penilaian terhadap kebolehppercayaan instrumen pengukuran bagi kursus Kalkulus Vektor Untuk pelajar kejuruteraan menggunakan model pengukuran Rasch. *Proseding Seminar Pendidikan Kejuruteraan dan Alam Bina*, 212-218.
5. Boopathiraj, C.; and Chellamani, K. (2013) Analysis of test items on difficulty level and discrimination index in the test for research in education. *International Journal of Social Sciences and Interdisciplinary Research*, 2(2), 189-193.
6. Wilson, M. (2005). *Constructing measures: An item response modelling approach*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.
7. Sulaiman, S.; Sulaiman, S.; Lazam, M.; and Azwan, M.N. (2006). Pengelasan tahap kesukaran soalan menggunakan rangkaian neural. *Proceedings of the 1st International Malaysian Educational Technology Convention*. Johor, Malaysia, 357-363.
8. Zainudin, S.; Ahmad, K.; Ali, N.M.; and Zainal, N.F.A. (2012). Determining course outcomes achievement through examination difficulty index measurement. *Procedia-Social and Behavioral Sciences*, 59, 270-276.
9. Mitra, N.K.; Nagaraja, H.S.; Ponnudurai, G.; and Judson, J.P. (2009). The level of difficulty and discrimination indices in type a multiple choice questions of Pre-Clinical Semester 1 multidisciplinary summative test. *International E-Journal of Science, Medicine and Education*, 3(1), 2-7.
10. Davies, A. (1990). *Principles of language testing*. Cambridge, Oxford: Basil Blackwell Ltd.
11. McAlpine, M.; and Hesketh, I. (2003). Multiple response questions – allowing for chance in authentic assessments. *Proceeding of the 7th International CAA Conference in Christie, J. (Ed.)*. Loughborough University, Loughborough, 193-206.
12. Bachman, L.F. (1990). *Fundamental considerations in language testing*. Oxford: Oxford University Press.
13. Sang, M.S. (1995). *Asas Pendidikan 3: Penilaian dalam proses pendidikan*. Kuala Lumpur: Kumpulan Budiman Sdn. Bhd.
14. Anon, (2006). Modul 5 kesesuaian item dan ujian dlm. HBEF3203: Pengukuran dan penilaian dalam pendidikan. Retrieved November 10, 2015, from http://www.ppdhl.net/v2/images/fbfiles/files/kesesuaian_item_dan_ujian.pdf.
15. Loon, L.H. (2004). Penganalisan dan pentafsiran soalan selepas pemarkahan. Retrieved September 15, 2011, from <http://www.iiu.edu.my/ilc/?download=01-bm08.pdf>.