# Achievement of Course Outcome And Level Of Bloom Taxanomy In Pre-final Test Questions

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**Abstract**

*For every five years, the Faculty of Engineering and Built Environment in Universiti Kebangsaan Malaysia, a public university in Malaysia will update the structure of the undergraduate education curriculum in order to improve and enhance its teaching and learning methods. One important feature of this effort is the result of updating the mapping of the course outcome, the programme outcome and the level of Bloom Taxanomy. In this study, the achievements of the course outcome, prograame outcome and Bloom Taxanomy for Vector Calculus subject for semester 1 session 2015 / 2016 were assessed using the pre-final method. The pre-final test was conducted in the 14$^{th}$ week of the semester. A total number of five questions were given provided that each measures the level of understanding of Bloom Taxanomy from level 1 (knowlwdge) to stage 6 (creation). A total of 42 first year students from the departments of Electrical, Electronic and System Engineering programs participated in the pre-final test results were analyzed using the Reasch measurement model. The study found that all the questions fulfill the real purpose of the assessment. The conclusion of the study is that the pre-assessment of the achievement of both the course outcome and programme outcome should be made to ensure that the assessment tool for course outcome and programme outcome, in this case the exam questions, really evaluates what needs to be assessed.*

**Keywords :** Pre-final, Course Outcome, Vector Calculus, Bloom Taxanomy, Rasch Measurement

## I. Introduction

Vector Calculus is the earliest subject introduced to all engineering students in their first year of study. Students are familiarizing themselves with the Vector Calculus subject as they would study differentiation and integration at the pre-university level. Thus, pre-university education especially mathematics lies as the strong foundation for engineering mathematics subject at tertiary level. Many researches locally and internationally have commented on students' achievement and ability in achieving Course Outcome of a subject using the Rasch measurement model.

Nopiah et al. (2012) examined the reliability of examination questions and its impact on students' performance using the Rasch model. Students' performance not only depends on the students' ability to answer the examination questions but also on the relevance of the questions. To construct relevant questions that match students' level of thinking, a detailed analysis of the questions is needed. The study showed higher mean of students' performance compared to the mean of the questins. This means that students are able to answer examinations questions well within the syllabus of the course.

Ayob et al. (2011) measured students' learning ability on learning outcomes using psychometric evaluation. The item response theory was used to measure the psychometric properties of students' achievement. Students' psychometric relates to the achievement of Course Outcome and the achievement of Programme Outcome. Final examination papers KKKL 1124 Circuit Theory II were used to exhibit the results using the rasch analysis. Students who need extra attention were highlighted in this study. Therefore, these students could buils up their academic grades earlier on.

Azrilah (2012a) assessed students' total learning experience using Rasch analysis. The main construction of assessment includes the correlation to the infrastructure provided, soft skill development and personality traits. The survey was conducted on 100 randomly selected engineering students from Universiti Kebangsaan Malaysia (UKM) using a 5-point Likert style survey at the end of the semester. The findings show that students responded positively on their total learning experience. This study focused on the students' soft skill development and reveal that they excel in social responsibilities. However, students were found to be lacking in entrepreneurial skills.

Azrilah (2012b) discussed the assessment of engineering students in UKM over their 20 weeks of industrial training. The sample consists of 305 employers who evaluated the industrial training students. Training students were from the mechanical, civil, electrical and chemical engineering departments. Employers assessed the training using a questionnaire that includes personal attitude, communication and work attitude. A total of 20 criteria questions included in the questionnaire and the output were run in the Rasch measurement model. Findings indicate that the capability to take responsibility as a group leader was very challenging for the industrial trainees. The easiest task was the ability to follow employer's instructions.

Izamarlina et al. (2011) found engineering students in the first semester in UKM to be lacking in knowledge in certain important topics in mathematics. Other than improving the teaching and learning methods and also the course learning outcomes, the construction of examination questions should be given consideration. The final

exam questions of KKKQ 2114 Engineering Mathematics III (Differential Equation) were analyzed using the Rasch modeling measurement. The distribution and separation of questions across the content and the classification of questions by Bloom Taxanomy level was monitored. Since there exists a big gap between several Bloom's cognitive skills levels, the level of difficulty for each cognitive skill need to be revised.

According to Osman et al. (2011), student's performance, in particular the difference of learning abilities between genders was one of the focuses in UKM.66 third year students from the department of civil and structural engineering from UKM were involved in this study. The sample of 66 students can further be divided to 30 males and 36 females, respectively. Students' knowledge and understanding for the subject KH 3273, Reinforced Concrete Design was examined and tallied with final exam results. This study concludes that male students had shown better performance in Reinforced Concrete Design course compared to female students.

Assessments of Course Outcomes are usually based on final exam grades. Saibani et al. (2011) manipulated the Rasch based measurement model as the assessment tool to measure the Course Outcome for KP 3423 Facilities Planning & Material Handling. The assessment includes the final exam, midterm exam, integrated projects and assignments. The study resulted in achieving all the Course Outcomes. This study also found that half of the total students were not being challenged by the course Outcomes as their capabilities were beyond the expectation level of all Course Outcomes. Another point is that each Programme Outcome for a particular course must address different levels of requirements.

According to Nik and Nangkula (2012) the assessment and measurement in teaching and learning process are important to ensure continuous quality improvement in education. Yet, the cumulative grade point average (CGPA) which is based on the mean of raw scores lacks the precision and linearity and it has no validity in measurement. Therefore, Rasch, a well-known model for validity in measurement was used to assess students' ability and the quality of questions in the Environmental Science examination at an architectural school. Although the Rasch model proved to be a reliable tool for assessing the students' ability they were unable to answer most of the questions. Thus examination questions should be revised to match students' capabilities.

Osman et al. (2012) conducted a questionnaire survey done on 273 engineering students from mechanical, civil, chemical and electrical engineering departments of UKM who attended the industrial training program. This study measures students' knowledge and skill pre-postindustrial training. The Rasch model analysis established that the person mean value as higher after the training session. Thus the level of knowledge and skills of students increased after the training program. The program provided extra knowledge and skills that students cannot find from the university's environment. The rasch analysis gave a detailed analysis on the preparation of every student before and after the training.

## II. Methodology

A pre-final test was conducted on the first semester of 2015/2016 session for engineering students. The test was given at the end of the semester which is on week 14. The pre-final test questions were conducted for Vector Calculus (KKKQ1124) subject.

A total of five subjective questions was designed and validated by two lecturers who teach the subject. The questions were set up for two hours and they totaled 40 marks. A total of 42 students from the Department of Electrical, Electronic and Systems (JKEES), Universiti Kebangsaan Malaysia (UKM) had participated in the test.

Programme outcomes are broad statements of what the students are expected to do, know, or develop as values for them when they graduate from a program. Course outcomes (CO) should clearly relate to the program outcomes (PO) and the statements are more detailed then the programme outcome. CO specifically defines what students should be able to do or know upon the completion of the course. There are 12 POs for engineering courses. However, for engineering mathematics courses, the focus is only on two POs, which are PO1 and PO2. A total of six Cos are designed for the Vector Calculus course. These POs and Cos were used as a guide to construct the test questions. Since the assessment for CO1 is through e-learning it is excluded for this study. Table 1 shows the Cos for Vector Calculus course. Table 2 shows the list of POs for engineering courses.

**Table 1.**Course Outcome for Vector calculus subject

| CO | Description |
|---|---|
| 1 | Understand the basic of surfaces in space. |
| 2 | Able to apply the basic concepts of partial derivatives. |
| 3 | Understand and able to apply the concepts of vector function, vector field, scalar field, gradient, divergence and curl. |
| 4 | Able to apply the concepts of line integral, double integral and triple integral in solving engineering problems. |
| 5 | Able to apply Green's Theorem, Stokes' Theorem and Gauss Theorem in solving engineering problems. |
| 6 | Understand the basic concepts of differentiation and integration of complex functions. |

**Table 2.** Programme Outcome for Vector Calculus subject

| PO | Description |
|---|---|
| 1 | Engineering knowledge |
| 2 | Problem analysis |
| 3 | Design / development of solutions |
| 4 | Investigation |
| 5 | Modern tool usage |
| 6 | The engineer and society |
| 7 | Environment and sustainability |
| 8 | Ethics |
| 9 | Communication |
| 10 | Individual and team work |
| 11 | Life long learning |
| 12 | Project management and finance |

As a first step, grades were compiled in the Excel *prn format. The grades were transferred using Bond & Box Steps as stated in Bond and Fox (2006) which known as WINSTEPS. It is a Rasch analysis software used to obtain the logit values. In the Rasch model, the probability of success can be estimated for the maximum likelihood of an event as

$$P(\theta) = \frac{e^{\beta_n - \delta_i}}{1 + e^{\beta_n - \delta_i}}$$

Where $e$ refers to the base of the natural algorithm or Euler's number of 2.7183, $\beta_n$ represents student's ability while $\delta_i$ is an item or task difficulty.

The details of the pre-final test questions and the distribution of marks are given in Table 3. There were total of 5 questions being tested and each question was related to one CO. In general, there are six levels of Bloom's Taxanomy namely knowledge, comprehension, application, analysis, evaluation and creation. Table 4 shows the details of pre-final questions together with Cos, Pos and the level of Bloom's Taxanomy. The test was constructed based on Bloom's Taxanomy and for this particular course only four domains are used; application, comprehension, analysis and evaluation.

**Table 3.** Pre-test questions

| Question | Description | Marks |
|---|---|---|
| 1 | If a specific case of Van der Waal's equation is given by $\left(P+\frac{14}{V^2}\right)(V-0.004)=12T$, determine the rate of change in pressure due to an increase of one degree. | 6 |
| 2 | Given $\mathrm{r}(t)=2\cos(2t)i+2\sin(2t)j+3t,$ $0\le t\le\pi$, | |
| (i) | Describe the projection of the curve on the $xy-$plane. | 2 |
| (ii) | Sketch the curve traced by $\mathrm{r}(t)$ and indicates the orientation and positions on the curve where $t=0, \frac{\pi}{2}$, and $\pi$. | 4 |
| 3 | Evaluate $\iint_S (z-y^2)dS$ in which is the portion of the paraboloid $z=x^2+y^2$ below $z=4$. | 10 |
| 4(i) | Sketch the region $R$, bounded by $x^2+y^2=1$, $x^2+y^2=4$, $x=0$ and $y=0$. | 2 |
| (ii) | Justify whether Green's theorem is applicable to compute the work done by the force. | 4 |
| (iii) | Hence, compute the work done by the force $\mathrm{F}=-xy^2i+x^2yj$, moving clockwise around the boundary of $R$. | 8 |
| 5 | Use the Cauchy-Reimann equation to determine whether the function $f(z)=x^2+y^2+2xyi$ is differentiable. | 4 |

**Table 4.** Entry number for each question

| Question | CO | PO | Level of Bloom's Taxanomy | Description |
|---|---|---|---|---|
| 1 | 2 | 1 | 3 | Application |
| 2(i) | 3 | 1 | 4 | Analysis |
| 2(ii) | 3 | 1 | 3 | Application |
| 3 | 4 | 1 | 5 | Evaluation |
| 4(i) | 5 | 2 | 3 | Application |
| 4(ii) | 5 | 2 | 5 | Evaluation |
| 4(iii) | 5 | 2 | 2 | Comprehension |
| 5 | 6 | 1 | 3 | Application |

## III. Results and Discussion

The Rasch analysis is divided into three parts, where the first part is called the" Person Measure", the second part is the "Item Measure" and the last is "Person Item Distribution Map". These outputs are extracted from Bond & Fox Steps (2006).

Figure 1 shows the summary statistics for individuals. Individuals represent the students who took Vector Calculus course. The person summary reveals a weak reliability of Cronbach Alpha=0.36 and person reliability=0.35. A reliability value below 0.7 indicates that the students provide irregular response to the items. At the beginning, we expect all the students to be able to answer the question as they gone through the entire syllabus since the test was given on week 14, but apparently, they could not. Some questions are likely answerable, but they can also be answered successfully.

The major finding showed that the person mean, $\mu_{person} = -0.26$ which shows that the students were found not performing well in answering the final questions. The negative logit reflects that students' performance is lower than the expected performance. This value also indicates that the students failed to achieve the Blooms achievement in the Cos and the students were less competent.

The result of separation was 0.74 indicating that the students could not be divided into any group and could not be well distinguished since the value was less than 1.0 logit. Logit forms equal interval linear scale. They have the same ability. Therefore, the rating scale applied will be revised for the study. The maximum or the highest item on the difficulty logit ruler is at +0.80 logit while the minimum or the lowest item is located at -1.08 logit. The difference between the maximum and minimum measures is 0.28 showing that the students are in "moderate" category. This indicates that the measurement ruler of students' ability is similar or homogeneous.

SUMMARY OF 42 MEASURED Persons

| | RAW | | | MODEL | INFIT | | OUTFIT | |
|---|---|---|---|---|---|---|---|---|
| | SCORE | COUNT | MEASURE | ERROR | MNSQ | ZSTD | MNSQ | ZSTD |
| MEAN | 20.7 | 8.0 | **-.26** | .29 | .96 | -.1 | 1.31 | .4 |
| S.D. | 4.9 | .0 | .41 | .03 | .69 | 1.2 | 1.99 | .8 |
| MAX. | 34.0 | 8.0 | **.80** | .35 | 2.59 | 2.1 | 9.90 | 3.0 |
| MIN. | 12.0 | 8.0 | **-1.08** | .26 | .09 | -2.6 | .10 | -.6 |
| REAL RMSE | .33 | ADJ.SD | .24 | **SEPARATION** | **.74** | **Person RELIABILITY** | | **.35** |
| MODEL RMSE | .29 | ADJ.SD | .29 | SEPARATION | .99 | Person RELIABILITY | | .49 |
| S.E. OF Person MEAN = .06 | | | | | | | | |

Person RAW SCORE-TO-MEASURE CORRELATION = 1.00

**CRONBACH ALPHA** (KR-20) Person RAW SCORE RELIABILITY = **.36**

**Fig. 1:** Summary statistics for individual

Figure 2 shows the summary statistics for the items involved in this study. “Items” represents the questions tested on the pre-final test. The item summary well summarises the very high reliability of 0.93 and item separation =3.66. The value of item separation indicates that there are four groups classifiable from the questions as “very difficult”, “difficult”, “moderate” and “easy”. The value for mean item is 0. The maximum item or the highest location of the item on the logit ruler was +1.26 logit and the minimum or the lowest item on the ruler was located at -1.06 logit.

SUMMARY OF 8 MEASURED Items

| | RAW | | | MODEL | INFIT | | OUTFIT | |
|---|---|---|---|---|---|---|---|---|
| | SCORE | COUNT | MEASURE | ERROR | MNSQ | ZSTD | MNSQ | ZSTD |
| MEAN | 108.7 | 42.0 | **.00** | .15 | 1.04 | -.1 | 1.31 | .4 |
| S.D. | 51.2 | .0 | .71 | .08 | .26 | 1.2 | .59 | 1.1 |
| MAX. | 190.0 | 42.0 | **1.26** | .36 | 1.45 | 1.4 | 2.15 | 1.5 |
| MIN. | 45.0 | 42.0 | **-1.06** | .10 | .65 | -2.5 | .55 | -1.9 |
| REAL RMSE | .19 | ADJ.SD | .69 | **SEPARATION** | **3.66** | **Item** | **RELIABILITY** | **.93** |
| MODEL RMSE | .17 | ADJ.SD | .69 | SEPARATION | 4.01 | Item | RELIABILITY | .94 |
| S.E. OF Item MEAN = .27 | | | | | | | | |

**Fig. 2:** Summary statistics for items

Person problem-solving skills and item difficulty were mapped side by side on the same vertical line with logit unit. Figure 3 refers to the Person-Item Distribution Map (PIDM). The discussion aims at the performance of the item with all of the 5 questions spread on the logit scale. The scale for the items is made up of samples ranging from 1.26 to -1.06 where the most difficult item and the ablest exam takers were laid out on top on top of the scale.

On the left side, each student was represented by their metric number for example A155835 representing a student who took the Vector Calculus pre-final test. The right hand side illustrates the test item which was represented by numbers. For example, 4(iii) means the third part of question 4. From Figure 4, only 33% ( $n=14$ )students were measured above item mean, $\mu_{item}$ while 67% ( $n=28$ ) students were under $\mu_{item}$ .

PIDM shows that the pre-final test questions can be divided into four categories, namely very difficult, difficult, moderate and easy. Question 4(iii)was the most difficult question to be answered by the student. Question 1, question 3 and question 4(ii) falls into difficult category. Both question 2(i) and question 2 (ii) were considered as moderate to answer. The easiest questions for the students are question 4(i) and question 5.

In terms of the correlations and comparisons between person and item, it is found that none of the students can answer the question which was identified as the most difficult question 4(iii). Five students A154971, A152419, A155370, A155393 and A155415 failed to answer the easiest question. It is also noted that, there is a huge gap between the two questions 4(ii) and 4(iii) denoted by the arrow indicating the extent of difficulty that the students encountered in attempting the questions as shown in Figure 3. These questions belong to categories of ‘difficult’ and ‘very difficult’. The gap indicates that the students have the difficulties in answering the questions given in the pre-final test.

In terms of course outcomes, CO2, CO4 and CO5 fall into difficult and very difficult categories. Students are weak at partial derivatives, line integral, double integral, triple integral, Greens’ theorem, Stokes’ theorem, Gauss’ theorem. It is also noticed that students are poor at the comprehension, application and evaluation levels of Bloom Taxanomy questions. More questions need to be given to the students for practice.

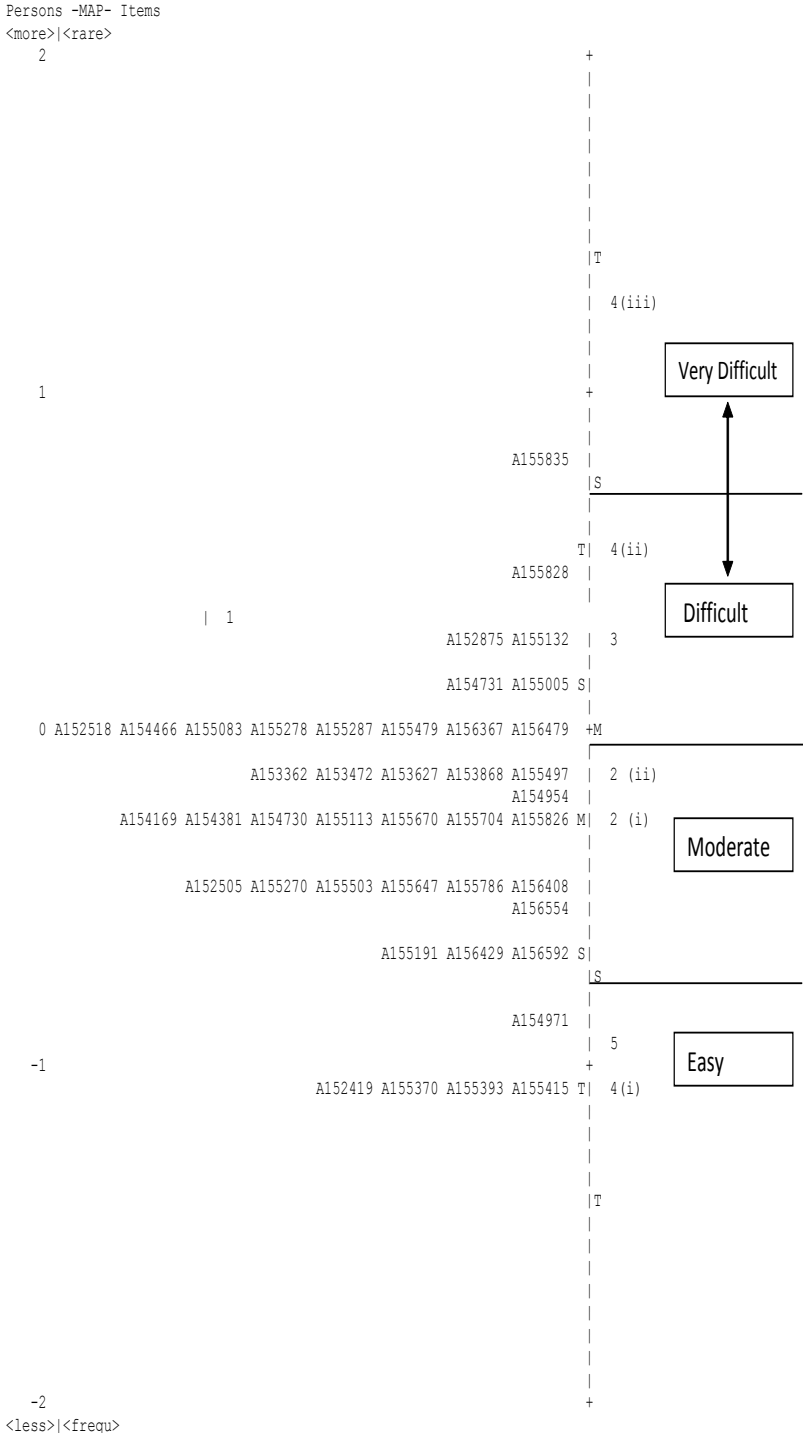


**Fig. 3:** Person-Item Distribution Map

## IV. Conclusion

The present study brings an important conclusion where the pre-final testquestions (items) for Vector Calculus (KKKQ 1124) course were designed and constructed well and found to be very reliable as no items were identified as misfit.
In this study, preliminary findings show that the persons and items involved in the study have good problem-solving skills and different levels of difficulty spread, with an eigenvalue of the raw variable explained by the measure showing more than 40%. This indicates that the sample and the items are reliable in measuring the students' problem-solving skills.

The person reliability 0.35 shows that the items are insufficient. To increase the person reliability, the number of questions and students should be added to this study. However, the performance of the fresh undergraduate students is lower than expected as their mean person at 0.26 logit measures. This indicates that students could not answer all the questions within the CO and PO.

The person-item distribution map reveals that the students cannot be divided into groups as the person separation is less than 1. Nevertheless, there is no misfit in this pre-final test, yet the questions / items level of difficulty should be revised and improved, so that the gap between 4(ii) and 4(iii).

All the CO and PO are tested well with the Bloom Taxanomy description in the pre-final test questions. The Rasch model enables each question (item) to be evaluated discretely and it is related to the Vector Calculus course. Even though the person reliability was categorized as weak, the item reliability is shown as excellent in the item reliability, therefore appropriate actions should be taken such as by increasing the number of items and students in this study. By applying the model, this study, again, is able to identify the pre-final test questions / items of difficulty for the students. In conclusion, the Rasch model has been a very useful to verify the reliability of the pre-final test questions for the Vector Calculus course.

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