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# Evaluation of Pilot Test on Improving Students' Performance Using Rasch Model

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***Abstract*---**Poor performance of students in Engineering Mathematics can be overcome by introducing innovative way in teaching. Teaching Engineering Mathematics via lab has been proven to boost the students' performance in Engineering Mathematics. Thus, the objective of this study is to conduct a pilot test to evaluate students' knowledge prior to introducing lab session to engineering undergraduates. A pilot test was conducted on third semester students in engineering faculty. A total of 35 students from Electrical Engineering, Civil Engineering and Chemical Engineering participated in the pilot test. Six course outcomes are chosen from Vector Calculus, Linear Algebra and Ordinary Differential Equations subjects. Six subjective questions were prepared and the questions were validated by three internal experts. The results of the test were analyzed against Rasch model. The item reliability 0.69 shows an average difficulty of spread of the pilot test questions. Furthermore, the summary statistics for item shows the questions can be separated into two different groups. The person-item distribution map shows that the distribution of questions categorized into difficult and easy groups. Question1 and question 2 fall into easy group. Question 3, question 4 and question 5 and question 6 fall into difficult group. Students faced difficulties in understanding power series and partial derivatives. Students also had tough time in applying line integral, double integral and triple integral in engineering applications. For future work, 60 Electrical Engineering students will be selected for a

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study and they will be divided into control and experiment group to experience teaching of Engineering Mathematics via lab.

***Keywords*---**pilot test, engineering mathematics, course outcome, performance, rasch model.

## Introduction

Poor performance of students in Engineering Mathematics can be overcome by introducing innovative way in teaching. Teaching Engineering Mathematics via lab has been proven to boost the students' performance in Engineering Mathematics. The Rash model has been used extensively in evaluating students' performance in examination (Nuraini et al., 2013). If students' performance is higher than the mean of questions it means that the students able to answer the examination questions within the examination scope (Osman et al., 2012). If the students' performance is lower than the mean questions then the students' understanding on the subject need to be improved (Bansilal, 2015). Individual validity can be determined by individual statistics which indicate inconsistent individuals in answering the question (Said, 2014). An item or question that does not match in a test can also be identified through an analysis of the Rasch model (Said, 2014; Haliza et al., (2012).

A study discusses on the evaluation of engineering students in industrial training for 20 weeks (Azrilah et al, 2012). The findings show that the ability to take responsibility as a group leader is a challenging task for industrial training students. The simplest task is the ability to follow the employer's instructions. A study conducted to evaluate the overall student learning experience using the Rasch model (Azrilah et al., 2012a). Construction of key assessments includes the correlation to the infrastructure provided, the development of soft skills and personality traits. The study focuses on the soft skills of the students and reveals that they are proficient in the aspect of social responsibility. However, students are found to be weak in entrepreneurial skills. The objective of this study is to evaluate the results of a pilot test on improving students' performance using Rasch model. The next step of this study is to conduct a pre-test for electrical engineering students. After the pre-test the students will be divided into control and experiment group. The lab session for Engineering Mathematics subject will be done via programming language.

## Methodology

A pilot test for was conducted in semester II 2016 / 2017. A total of 35 students from Electrical Engineering, Civil Engineering and Chemical Engineering department participated in the test. Exam questions were constructed based on Course Outcome and Programme Outcome. The questions were validated by three internal experts. The duration of the test was 2 hours and 6 subjective questions were prepared. The pilot test questions were from moderate and easy level. The profile of the students who took the pilot test as listed in Table 1.

Table 1
Profile of students

| Department | Number of Students |
|---|---|
| Electrical Engineering | 13 |
| Chemical Engineering | 12 |
| Civil Engineering | 10 |
| Total | 35 |

Table 2 list the Course Outcome for the pilot test. These Course Outcomes are combination of Vector Calculus, Linear Algebra and Ordinary Differential Equation subjects.

Table 2
Course outcome for pilot test

| Course Outcome | Description | Subject |
|---|---|---|
| 1 | Able to apply Green's theorem, Stokes' theorem, Gauss' theorem in solving engineering problems. | Vector Calculus |
| 2 | Able to use the concepts of vector space, linear independent in the space dimension and matrix transformation. | Linear Algebra |
| 3 | Able to understand the concepts of power series. | Linear Algebra |
| 4 | Able to understand the concepts of partial derivatives. | Vector Calculus |
| 5 | Able to solve first and second orders of ordinary differential equations. | Ordinary Differential Equations |
| 6 | Able to apply the concepts of line integral, double integral and triple integral in solving engineering problems. | Vector Calculus |

Table 3 shows the Programme Outcome for the pilot test questions. There are a total of 12 Programme Outcomes for the Engineering Programme.

Table 3
Programme outcome for pilot test

| Programme Outcome | Description |
|---|---|
| 1 | Engineering knowledge |
| 2 | Problem analysis |
| 3 | Design / development of solutions |
| 4 | Investigation |

| Programme Outcome | Description |
|---|---|
| 5 | Modern tool usage |
| 6 | The engineer and society |
| 7 | Environment and sustainability |
| 8 | Ethics |
| 9 | Communication |
| 10 | Individual and team work |
| 11 | Lifelong learning |
| 12 | Project management and finance |

Table 4 illustrates the distribution of pilot test questions together with the marks.

Table 4
Pilot test questions

| Q | Description | Marks |
|---|---|---|
| 1 | Use the Green Theorem to evaluate $\int_C xydx + x^2y^3dy$ ; where C is a triangle with vertices (0,0), (1,0), (1,2). | 6 |
| 2 | Compute the projection of (1, 2, 3) onto (-2, 3, -1) using inner product $<\mathbf{a},\mathbf{b}>= 2a_1b_1 + 3a_2b_2 + 4a_3b_3$. | 6 |
| 3 | Obtain power series representation of $x^5$ in power of $x-2$. | 6 |
| 4 | The plane tangent to the surface defined by $z = f(x,y)$ at the point $(x_0, y_0, z_0)$ is $z = z_0 + f_X(x_0,y_0)(x-x_0) + f_Y(x_0,y_0)(y-y_0)$. Determine the equation of the plane tangent to the paraboloid $z = 10 - x^2 - 2y^2$ at the point where $x = 1$ and $y = 2$. Sketch the plane tangent and the paraboloid. | 9 |
| 5 | Solve the equation $\frac{dy}{dx} = x + y$ with initial condition $y(0) = 2$. Then plot the solution. | 9 |
| 6 | Find the volume of the solid that lies under the paraboloid $z = x^2 + y^2$, above the $xy-$ and inside the cylinder $(x-1)^2 + y^2 = 1$. | 12 |

The details entry of each pre-final question is given in Table 5. The table shows the questions, Course Outcome, Programme Outcome and the level of difficulty of each question.

Table 5
Entry number for pilot test questions

| Question | Course Outcome | Programme Outcome | Difficulty Level |
|---|---|---|---|
| 1 | 1 | 2 | Moderate |
| 2 | 2 | 1 | Easy |
| 3 | 3 | 2 | Moderate |
| 4 | 4 | 1 | Moderate |
| 5 | 5 | 1 | Moderate |
| 6 | 6 | 1 | Moderate |

**Results and Discussion**

All the marks are entered in the Excel *prn format. This file was transferred using Bond & Fox Steps (2006), which is a customized WINSTEPS. The WINSTEPS provides detail description on Summary Statistics for Item and Person-Item Distribution Map. Summary statistics for item gives detail description of the items (questions) and the persons (students). Figure 1 shows the summary statistics for items.

From Figure 1, the summary statistics reveals an average spread of item difficulty with item reliability of 0.69. Higher value of item reliability increases the possibility of the item having similar attempt when given similar test (Linacre, 1994). This means among the pilot test questions there are some which is difficult and some which easy. The spread of the items is from minimum logits of -0.82 to maximum logit at 1.08. Item mean (measure) is 0. The item separation indicates number of the groups the question can be divided. The summary statistics shows that the item separation is 1.49. This means the pilot test questions can be divided into 2 group.

```
SUMMARY OF 5 MEASURED (NON-EXTREME) Item
-------------------------------------------------------------------------------
|          TOTAL                          MODEL          INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE   ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN      53.2      35.0         .00     .32       .80    -.1    .94     .0 |
| S.D.      17.2        .0         .71     .23       .23     .6    .56     .8 |
| MAX.      77.0      35.0        1.08     .75      1.16     .8   1.97    1.3 |
| MIN.      36.0      35.0        -.82     .14       .53   -1.1    .44   -1.3 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .39 TRUE SD     .59  SEPARATION  1.49  Item   RELIABILITY  .69 |
|MODEL RMSE    .39 TRUE SD     .59  SEPARATION  1.50  Item   RELIABILITY  .69 |
| S.E. OF Item MEAN = .35                                                     |
-------------------------------------------------------------------------------
```

Figure 1. Summary statistics for items

Figure 1 shows the Person Item Distribution Map where Rasch model provides the location of all the person on the vertical logit ruler, indicated by the dashed vertical line. The higher the person located on the map, it indicates the most

competent the student is. On the contrast, the item is like the hurdle to the students. The higher the item is on the ruler, the more difficult the question is.
The discussion aims at the performance of the item of all the 6 questions spread on the logit scale. On the right hand side of the dashed line, the questions are aligned from easy to difficult, starting from the bottom. The distribution of students is on the left side of the vertical dashed line is increasing the order of ability. Letter 'M' describes the students and item mean, 'S' is one standard deviation distance from the mean and 'T' marks two standard deviation distances from the mean. CH01 means a student who took the pilot test from chemical engineering department, EE11 means a student from the electrical engineering department and CV03 means a student from civil engineering department.

From Figure 3, the questions can be divided into 2 groups. In order to establish the cut-off point of the 2 groups on the logit ruler, it starts from the mean item 0.00 logit. At mean 0.00, Rasch model established a virtual zero of the logit ruler (Aziz, 2009). At this point, given a task, a person has 50:50 chance of success in performing the task, before he decides based on his experience that he may or may not be able to complete the task.

Questions above the mean line are defined as being in the 'difficult' category. From a total of 6 questions, 4 questions fall into the 'difficult' category. The questions in the 'difficult' category are question 3, question 4, question 5 and question 6. On the other hand, questions below the mean line are easy for the students to answer during the pilot test. Question 1 and question 2 are the ones deemed easy to solve.

In terms of the Course Outcomes, Course Outcome 1 and Course Outcome 2 fall into the easy category. Students find easy to apply Green's theorem, Stokes' theorem and Gauss' theorem in engineering applications. Students also find easy to use the concept of vector space, linear independent in the space dimension and matrix transformation.

Course Outcome 3, 4, 5 and 6 very difficult for the students. Students find difficult to understand the power series and partial derivatives. Students also face difficulties in applying the concept of line integral, double integral and triple integral in engineering applications. Solving first and second order of differential equations are also difficult for the engineering students. Table 6 summarizes the results of Person-Item distribution map.

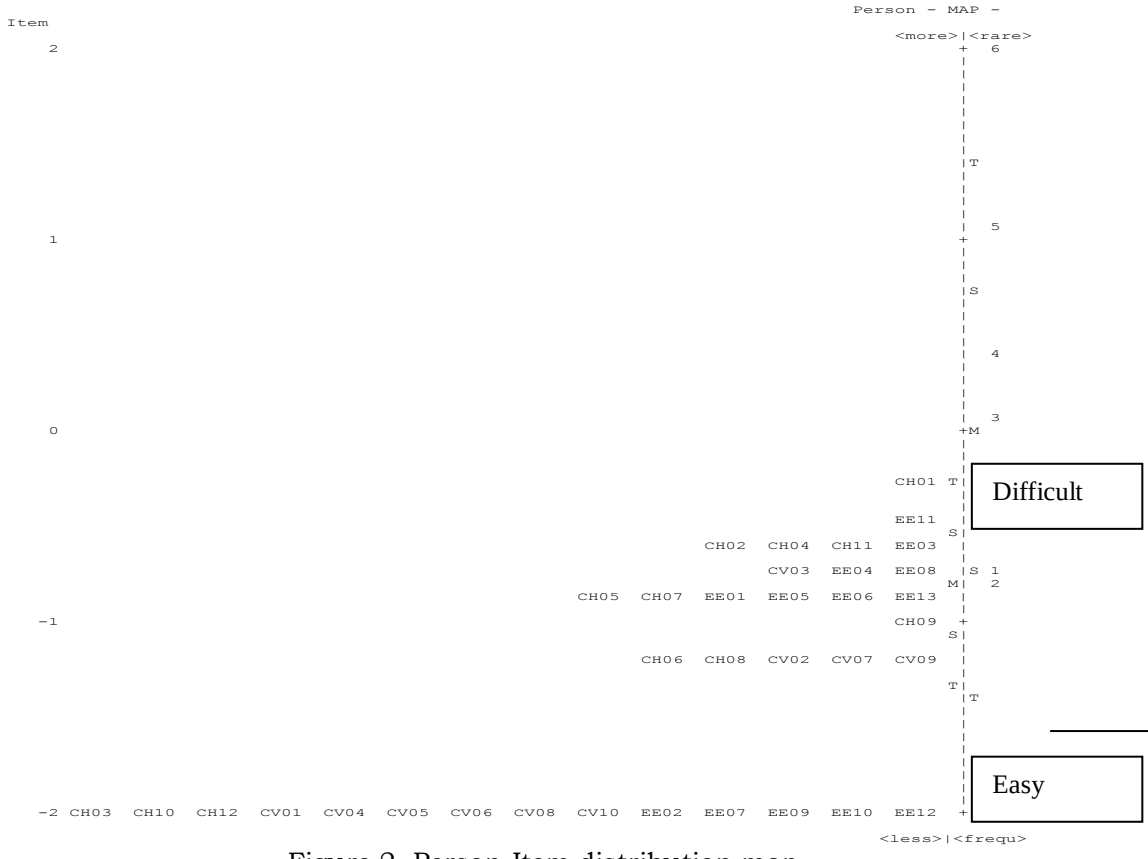


Figure 2. Person-Item distribution map

Table 6
Summarizes the results of the person-item distribution map

| Q | Course Outcome | Subject | Difficulty Level of Question | Difficulty Level from PIDM |
|---|---|---|---|---|
| 1 | Able to apply Green's theorem, Stokes' theorem, Gauss' theorem in solving engineering problems. | Vector Calculus | Moderate | Easy |
| 2 | Able to use the concepts of vector space, linear independent in the space dimension and matrix transformation. | Linear Algebra | Easy | Easy |
| 3 | Able to understand the concepts of power series. | Linear Algebra | Moderate | Difficult |
| 4 | Able to understand the concepts of partial | Vector Calculus | Moderate | Difficult |

| | | | | |
|---|---|---|---|---|
| | derivatives | | | |
| 5 | Able to solve first and second orders of ordinary differential equations. | Ordinary Differential Equations | Moderate | Difficult |
| 6 | Able to apply the concepts of line integral, double integral and triple integral in solving engineering problems. | Vector Calculus | Moderate | Difficult |

**Conclusion**

This study is a pioneer study before implementing teaching via lab sessions for Engineering Mathematics subject. This study analyzed a pilot study which consist of 35 students from engineering background. The six Course Outcome consists from different subjects of Engineering Mathematics which are Vector Calculus, Linear algebra and Ordinary Differential Equations. Thus six subjective questions were designed and validated by internal experts. The test results were analyzed against Rasch model. The summary statistics of items shows that the pilot test questions can be divided into two groups. The person-item distribution map further elaborates on the questions which belongs to the easy and difficult category. Power series, partial derivatives, first and second order of differential equations and line integral, double integral and triple integral are among difficult topics in Engineering Mathematics.

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