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Measuring Engineering Students' Ability and Attitude across Revised Blooms' Taxonomy with Rasch Measurement Model

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Abstract – one of the major problems faced by educational researchers is the right approach to learning. According to Bloom's theory of learning, there are six levels that the order of levels in proper learning is important. On the other hand, affective domains (students' attitude) in learning may be related to cognitive domains (actual ability). In this research, Rasch measurement model had been used to measure affective and cognitive domains of revised Blooms' taxonomy but it has not been extensively used in many survey investigations involving engineering calculus education research. This study had employed Rasch dichotomous and rating scale models to determine relationships between students' attitude based on cognitive levels and their competency in learning engineering mathematics. In this study, two type's data were measured. First type data is Students' attitudes that were measured by the 20 items as 5-point Likert scale. Second type data is students' competency that was measured by students to answer correctly or incorrectly based on two topics of engineering calculus (III). This study used four engineering faculties' data which were formerly gathered from 342 students at three consecutive semesters in Universiti Teknologi MARA (UiTM). Item characteristic curves from data indicated that related data was fit Rasch model. Students' competency and attitude were investigated based on Person-Item-Distribution Map (PIDM). Rasch analysis had shown that students' attitude indicates that application level of cognitive and evaluation levels are the least and most difficult agreeable, and this result is almost identical to the same result in actual students ability, so that the evaluation level is the hardest, and the understanding and application levels are the most convenient levels, respectively.

Keywords-Engineering Mathematics, Rasch model, Revised Blooms Taxonomy, Person-Item Distribution Map, Item Characteristic Curve.

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1 Introduction

MATHEMATICAL science is the basis of all other sciences. It is near impossible for people to Keep up in today's world without at least some basic knowledge of mathematics. It is furthermore essential for those intending to pursue fields of science and business to have a strong foundation in mathematical sciences. One of the underlying issues in the process of teaching and learning is how to assess students' learning [1].

Mathematics courses are used as the practical application for students studying courses in engineering. That is, mathematics helps to strengthen and to accelerate students understanding in many varieties of engineering courses [2]. Hence, it is important and critical for students to achieve a strong mathematics background. The aim of teaching mathematics to engineer students is to achieve the right balance between the practical application of the mathematical equations and a deep understanding of the life situation [3].Good mathematical thinking has an impact on engineering students as their ability to use their skills in mathematics is important in pursuing their career as an engineer [4]. Learning can be into many different meanings depending on definitional opinion. Kirschenman and Brenner [5] defined engineering as "the application of mathematics and natural sciences to design and construction projects for use in the society". On the other hand, Cardella [4] claimed that students of engineering should be taught a mathematical model because they can use mathematics as a tool for designing and checking errors. Mathematics and engineering are closely related to each other and engineering mathematics denote relationships between the real world and mathematics. Zain.et al [6] pointed out that one important outcome of the attitudes research has indicated the correlation between attitudes toward science and student achievement in science and also future access to science experiences. There is a contribution to the study of attitudes toward learning mathematics was by Neale [7], who underlined that attitude plays a major role in learning mathematics and positive attitude towards mathematics is thought to play a crucial role in causing students to learn mathematics (p. 631). The question that still exists, however, is the simple matter of what and how to learn mathematics properly. Many methods and research have been done to solve this issue and this is still important for researchers. This study is expected to expose the attitude and actual ability of engineering students' measurement tools and reveal their relationships with using Rasch measurement.

2 BLOOM'S Taxonomy

Larsen [8] highlighted that learning mathematics is not only a cognitive challenge but also an affective one.Researchers have done some studies about teaching and learning. Burns [9] conceived learning as a stable change in behaviour that consists of observation and intervention process like thinking, attitudes and etc. Likewise, Sarason [10] believed that learning is a process, not a thing. mBloom et al. [11] classified development of human learning domains into three areas. a) Cognitive domain: consists of objectives that dealing with identification of knowledge and improvements of rational abilities and skills. b) Affective domain: consists of objectives that describe differences in attitudes; and interest, etc. c) Psychomotor domain: consists of manipulative or movement skill area. Bloom et al. [11] classified these three domains to some areas as shown in Fig. 1.

The revised Bloom taxonomy gives slightly different names to the 6 levels of the hierarchy, the last two categories have been reversed, putting create (synthesis) as the most complex level.[12] There are some challenges between educators about relationship between cognitive and affective domains of learning. Ma and Kishor [13] illustrated it is necessary to understand humans skills; however, cognition and affect domain had better not be a parted.

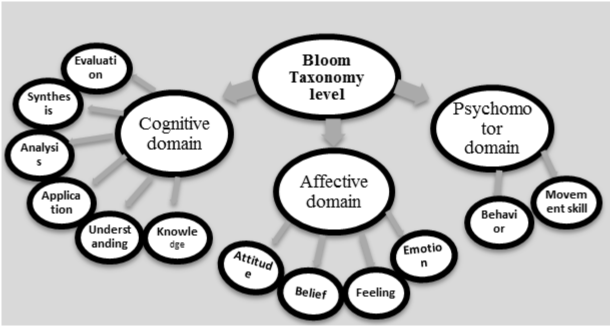

Figure 1: Fig. 1. Blooms' taxonomy levels for human learning

Some educators like as Gibbons, Kimmel and O'Shea [14], [15] pointed out attitudes towards relevant subject can be linked to achievement education in methods that support higher or lower performance. Even though Moenikia and Zahed-babelan[16] found that there are positive relationships between mathematics attitude and mathematics among 1670 students in the high school of Iran. Nicolaidou and Philippou [17] believed that researchers should find the relationship between attitude towards mathematics and achievement. Therefore, from most educators overview can be deducted even moderate fluctuations in positive feelings could systematically affect cognitive processing and so performance. Mathematics educators tend to believe that children learn more effectively when they are interested in what they learn and they achieve better if they like what they learn [18].Thus, students who come to enjoy Mathematics, increase their intrinsic motivation to learn and vice-versa[16],[17],[18]. This study is effort to maintain the quality of survey response data using the appropriate Rasch measurement tools such as Person-Item Distribution Map (PIDM) and item characteristic curve (ICC) [19],[20],[21],[22],[23].

3 Overview of RASCH Measurment Model

The Rasch Model is a latent trait model that is based on the students' performance can be determined by a latent trait. The latent trait enables students to correctly answer a question are usually ability, knowledge or attainment [19]. Applying Rasch model enables educators to develop and specify the relationship between the observable performance of students and the unobservable latent trait underling their performances. The Rasch Model predicts the probability of a student obtaining a correct answer on a question in terms of two parameters, one relating to the item difficulty on the test and the other to the students' ability [20]. The model based on the relationship between items difficulty and students' ability determines the performance of students on the desired test [21]. The important point in designing the model is that a student with greater ability should have a higher chance of success on a specific question than a less able person. The probability of the success of a student on an item can be specified as a function of the difference between the ability of the student and the difficulty of an item, where both ability and difficulty are measured on the same linear scale [24], [25]. Dichotomous and rating scale models are under Rasch model. Rating scale model is a Rasch model with more than two options where the difference between two parameters namely, person ability (δ_{ij}), item difficulty (β_{n}) and also X number of categories are governed by a single logit scale as a result of the log transformation of the probability of completing a task given the ability of a person and the difficulty of the task or item given in (1).

$$\pi_{\mathrm{nix}} = \frac{\exp \sum_{j=0}^{X} (\beta_n - \delta_{ij})}{\sum_{k=0}^{m_i} \exp \sum_{j=0}^{X} (\beta_n - \delta_{ij})} \tag{1}$$

[27],[28],[29],[30],[31]. Dichotomous model is a simple type of Rasch model which has two option for answering either a yes (1) or no (0), correct or incorrect, agree or disagree[32],[33]. The Rasch measurement model function based on Rasch (1960) is illustrated as follows:

$$P(X=1) = \frac{\exp(\theta_n - \delta_i)}{1 + \exp(\theta_n - \delta_i)} \tag{2}$$

where θ_n and δ_i are Person ability and item Difficulty [34], [35],[36].

4 Methodology

The sample in this study consisted of 432 engineering students who were enrolled in the Engineering' calculus in second-year students of the Mechanical, Electrical, Civil, and Chemical Engineering faculties at the Universiti Teknologi MARA (UiTM). A quantitative study was conducted using two instruments namely, (1) Attitude towards learning mathematics and (2) Competency test forms. Students' attitude towards learning mathematics which comprises of 20 items from Aiken Revised Math Attitude Scale towards Learning Mathematics were measured on a 5-point Likert-scale Ranging from1=Strongly Disagree, 3=Neutral to5= Strongly Agree across revised blooms taxonomy levels [37]. Students' attitudes towards learning mathematics were measured by the Rasch Rating Scale Model. In addition, the items in the competency test cover cognitive skills on remembering (7items) understanding (8 items), applying (8 items), analysing (5 items), evaluating (4 items) and creating (4items).The content areas include of two topics: infinite sequence and series and multiple integral. Rasch Dichotomous Model is used to measure students' competency in learning mathematics (engineering calculus III). The analysis was carried out in order to calibrate items difficulty and person ability for students' attitudes and students' competency across revised Blooms' taxonomy levels using Person-Item-Distribution (PIDM) for the endorsement of items and person responses. These instruments provide items with multiple answers. The Rasch Model framework using WINSTEPS version 3.72.3 was employed in this study.

5 Analysis and Results

The summary statistics was obtained for person and items in Tables I and II

Tables I and II present a high reliability index for students' competency (0.98) and a high attitude item reliability index (0.99). These are considered good index for

Table 1: Summary of 36 Engineering Calculus (III) Items

	person Measure	Item Measure	Item-Infit MNSQ	Item-Infit ZSTD	Item-Outfit MNSQ	Item-Outfit ZSTD
MEAN	-.41	.00	1.00	.2	.98	.0
S.D.	.64	1.04	.06	1.3	.10	1.3
MAX.	.97	2.13	1.14	4.4	1.18	4.0
MIN.	-3.26	-2.52	.85	-2.2	.75	-3.0
Item SEPARATION	7.80	Item RELIABILITY	.98			
Item SEPARATION	7.87	Item RELIABILITY	.98			

Table II:
Summary of 20 Students' Attitude Items

	person Measure	Item Measure	Item-Infit MNSQ	Item-Infit ZSTD	Item-Outfit MNSQ	Item-Outfit ZSTD
MEAN	1.16	.00	.98	-.3	.99	-.1
S.D.	.82	.75	.17	2.2	.17	2.0
MAX.	6.25	2.33	1.40	4.6	1.39	4.5
MIN.	-.40	-.81	.77	-3.4	.77	-3.0
Item SEPARATION	10.54	Item RELIABILITY	.99			
Item SEPARATION	10.84	Item RELIABILITY	.99			

items. The mean infit and outfit for competency and attitude items mean squares are expected to be 1.00, and for these data, they are all close to 1.00. The mean standardized infit and outfit are expected to be near 0.0. Tables I and II show the z-scores infit and outfit are 0.0 and -0.1 for students' attitude and students' ability, respectively.

Further analysis was carried out to look at the endorsement of the responses based on the Item Characteristics Curve (ICC). The selected expected and empirical ICC is chosen all items in measuring students' attitude towards mathematics in Figs. 2 and 3. This show the red curve is the item characteristic curve as expected by the Rasch model ICC. It is the Rasch-model prediction of how students at different abilities along the latent variable would have score on the item in the -axis, on average. The blue cross is the empirical data. Each display the responses of students on the -axis. These figures display that most blue crosses approximates the Rasch Model curve. Therefore, it indicates the almost items are fit the Rasch model.

Figures 2 and 3 show the person-item distribution map

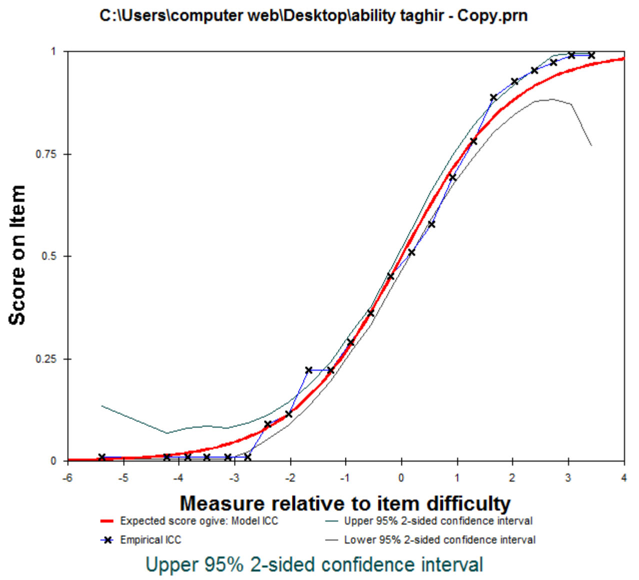

Figure 2: The expected empirical ICC for students' competency

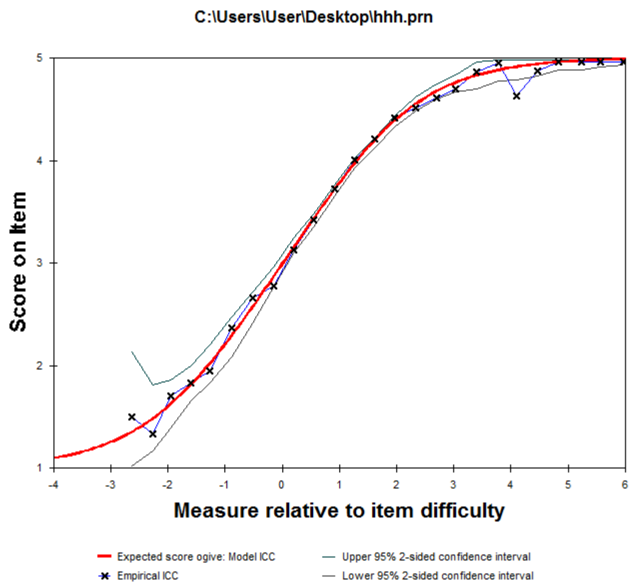

Figure 3: The expected empirical ICC for students' attitude

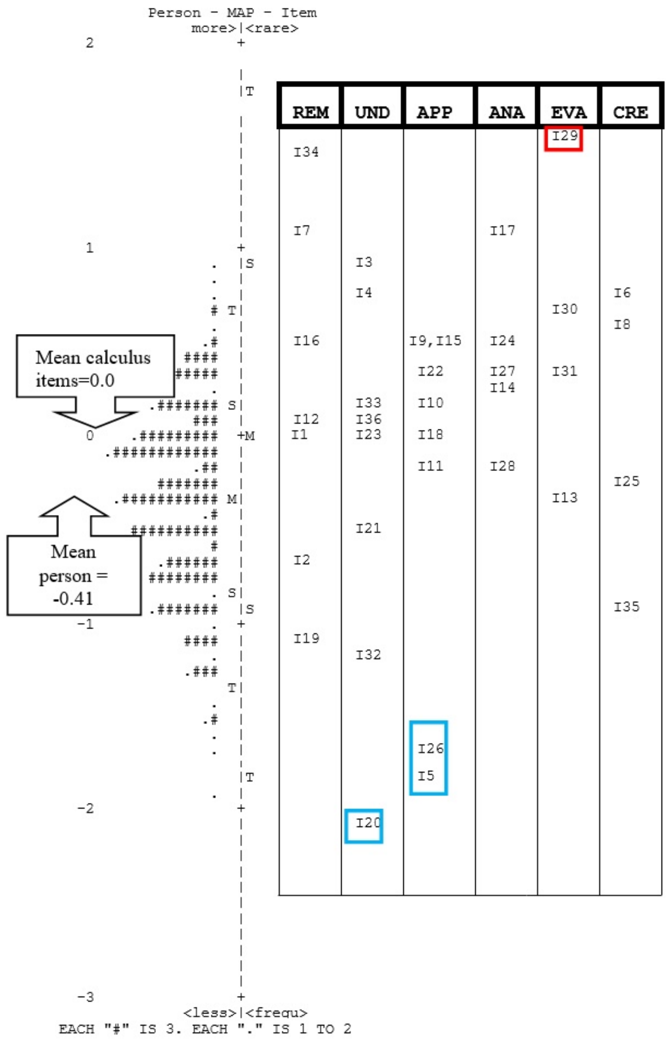

Figure 4: The expected empirical ICC for students' competency

of perceived understanding of calculus concepts. The maps display the distribution of students (on the left side of the maps) according to their ability from most able to least able in endorsing items as correct (Fig. 4) or agree (Fig. 5). The maps also display the items according to the difficulty or agreeable levels. From the Wright map in Fig. 5, all 20 items are distributed on the logit scale based on revised Blooms' taxonomy. A higher ranking item2 (on top) indicated which item is more difficult to endorse and vice versa. Item 2 under evaluation level located in the top of the map is associated with the most difficult item. On the other hand, items 3 and 8 under application level are the easiest items located in the lowest part of the logit scale. Response Items are categorized into six levels based on revised blooms taxonomy. In addition, Fig. 5 shows that a person's mean logit $\mu_{\text{students's competency}} = 1.16$ falls above the attitude items

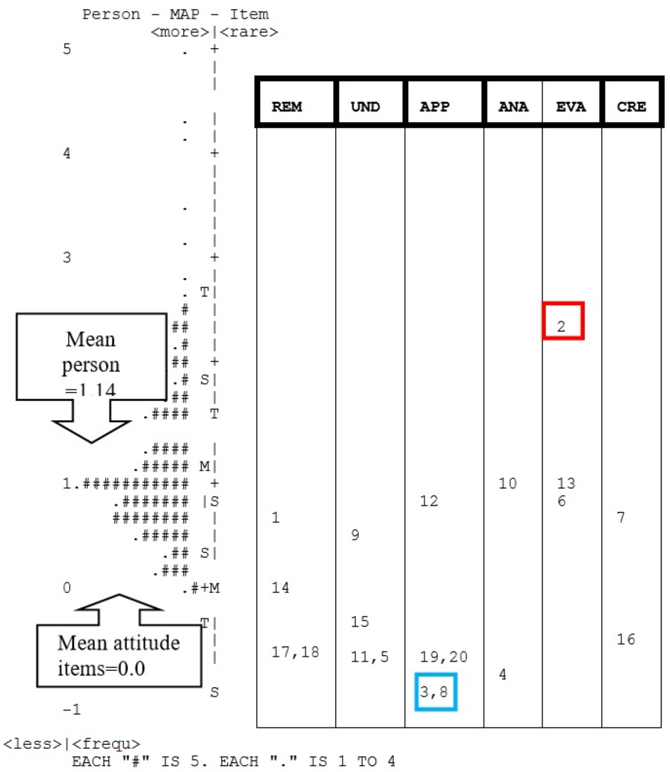

Figure 5: The expected empirical ICC for students' attitude

mean logit $\mu_{\text{attitudeitem's difficulty}} = 0.00$,is indicated the students are more likely to agree or endorse the items. On the other side, distributions of students' competency (dichotomous data) can be seen at Fig. 4 that Item 29 under evaluation level is the most difficult item when the students encountered to answer the question. While Item 20 related understanding, items 5 and 26 under application levels are the easiest items, respectively.

Indeed, person measure mean is located lower than calculus item measure mean. The analysis demonstrated that a person's mean logit $\mu_{\text{students's competency}} = -0.41$ falls below the calculus item mean logit $\mu_{\text{calculusits' difficulty}} = 0.0$as shown in Fig. 5. Therefore, it is indicated the answers to the calculus items are generally a bit difficult for students.

6 Conclusion

In the study on engineering students' attitude and competency in learning mathematics across revised Blooms' taxonomy levels, Rasch model has demonstrated its ability to identify and exclude misfit items and inappropriate responses with using item characteristic curve (ICC). The process of calibrating students' ability and item difficulty took place following the construction of the common logit scale ruler of person distribution item map. As a conclusion to this research it can be said that, since the students' positive attitude towards mathematics is at medium level, it shows that there are still possible room for improvement. However, it is interesting to know that despite the lower performance of engineering students in mathematics, the attitude of the respondents of this study is fairly positive. The research also shows that the students' attitude towards mathematics in application and evaluation levels is the most and least agree with items. These results have same direction with students' ability results that are the easiest in understanding and application levels and also the evaluation level is the most difficult. Therefore, students' attitude towards mathematics across revised Blooms' taxonomy levels does not have significant difference with students' competency towards revised blooms' taxonomy levels in engineering calculus(III) learning.

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