Evaluation of Mastery of Physics Concepts with the RACH Model: Analysis Approach Using J Metrics

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Abstract

This research aims to analyze mastery of understanding physics concepts in material motion kinematics material. Mastery of concepts is one of the important goals in the physics learning process. This research uses a case study approach with a post-test only one group design. The research sample consisted of 739 level 1 students. Instruments study consists of 28 multiple choice questions. The results of the research show that the majority of students have mastered the understanding of physics concepts the average ability is around -0.3032 to -0.0137 logit or lower than 0.0 logit. Scale theta covers a range from approximately -5.21 (for a score of 0) to 5.52 (for a score of 35). This means that students' abilities are distributed from very low to very high. Rasch models can be analyze mastery of understanding physics concepts well. Learning physics requires a learning process that can increase mastery of concepts.

Keywords: Understanding physics concepts, Rasch Model

INTRODUCTION.

Mastery of physics concepts is an important indicator in measuring the success of learning in the field of science. However, evaluating the mastery of concepts often face challenges, especially in ensuring accuracy and objectivity results. The Rasch Model, part of Item Response Theory (IRT), offers a quantitative analysis approach that is able to overcome the limitations of conventional evaluation. This model does not only measure student abilities individually, but also evaluates the level of difficulty of the questions and their suitability to students' abilities. By using the Rasch Model, analysis of mastery of physics concepts can be carried out more comprehensively, providing diagnostic information that is useful for improving the quality of learning.

Physics is a branch of natural science that plays an important role in helping students understand natural phenomena and the laws that govern the interaction between matter and energy. Understanding physics concepts not only supports critical and logical thinking skills, but also helps students develop applicable problem-solving skills.

Mastery of physics concepts is one of the main goals in the learning process, both at primary and secondary education levels. However, in practice, mastery of physics concepts often becomes a challenge, especially when the evaluation method used is unable to provide an in-depth picture of the relationship between students and the evaluation instrument.

One approach that can be used to evaluate concept mastery in depth is the Rasch Model, which is part of Item Response Theory (IRT). The Rasch Model allows objective quantitative analysis of student abilities and the level of difficulty of questions. This model works by mapping student abilities and the level of difficulty of questions on the same scale, thus providing more accurate information than conventional evaluation methods. The Rasch Model also allows the identification of inappropriate questions (*misfit*), which can be the basis for improving evaluation instruments. In addition, the Rasch Model approach provides advantages in terms of learning diagnostics. Through this analysis, educators can find out which concepts are most difficult for students to understand and design more effective learning strategies. Thus, Rasch Model-based evaluation not only functions to measure mastery of concepts, but also provides insights to improve the quality of learning. This research aims to analyze students' mastery of physics concepts using the Rasch Model. The main focus of this research includes measuring the difficulty level of questions, analyzing individual student abilities, and identifying inappropriate questions. It is hoped that the results of this research can contribute to the development of more effective physics evaluation and learning methods, objective, and relevant to student needs.

SCOPE

The scope of this research includes several main aspects related to mastery of physics concepts and the application of the Rasch Model, namely:

1. Physics Question Analysis This research includes an analysis of the difficulty level of physics questions based on student response data.
2. The ability to understand physics concepts can measure an individual student's ability to understand physics concepts. The data obtained is analyzed to determine the distribution of student abilities on the Rasch Model scale.

METHOD

Design study

This research was carried out in four study programs at the Health Polytechnic of the Ministry of Health, Jakarta II. The four study programs are the Applied Undergraduate Study Program in Radiological Imaging Technology, the Applied Undergraduate Study Program in Electromedical Engineering Technology, the Diploma 3 Study Program in Electromedical Engineering and the Diploma 3 Study Program in Radiological Engineering. This research uses the survey research method and research design used multiple linear regression. This design can be seen in Figure 1.

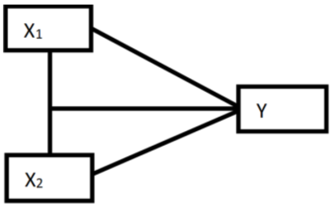

Figure 1. Research Design

X_1 = Perception of learning styles
X_2 = Interest in learning
Y = Understanding of physics concepts

MATERIALS AND METHOD

This research uses the one-shot case study research method with a posttest only research design one group design (Fraenkel, J. R., 2012 The total population in the study was 739 people. The researcher used an error rate of 10% for the research sample size. The total research sample was 88 level 1 students. Random sampling technique was used in the data collection technique. In this study, the sample is determined randomly by drawing lots and determining the number of samples from each class. The number of samples in each class is calculated using the formula physics. In this study, research instruments were used, namely questionnaires and tests. Questionnaires consist of questionnaire perception of learning style which is 32 questions and questionnaire interest in learning which amounts to 28 statements. Questionnaire using five answer choices with a Likert scale. The test instrument used to test the understanding of physics concepts consists of 35 multiple choice questions with material on motion kinematics. Instrument testing is carried out so that its validity, reliability, differentiation and level of difficulty can be determined. This research uses descriptive data analysis techniques. The characteristics of respondents' scores on each variable can be described. Next, data requirements analysis techniques were carried out by testing with the Rasch model.

RESULTS AND DISCUSSION

RESULTS

In accordance with the previous description, data analysis from the results of the concept understanding test regarding heat propagation used the Rasch model with the help of J Metrics. To determine the level of understanding of students' concepts, it can be analyzed using the output table and tables used, namely Table 17. Person Measure and Table 6. Person Fit Order (Sumintono & Widhiarso, 2015). In addition, students' achievement of conceptual understanding can be analyzed using output table 1.

A summary of overall descriptive data with the help of testing and calculations via the J Metrik application is shown in Table 1.

FINAL JMLE ITEM STATISTICS

Item	Difficulty	Std. Error	WMS	Std. WMS	UMS	Std. UMS
1	-0.30	0.22	0.77	-2.33	0.69	-2.42
2	2.05	0.26	1.31	2.14	2.75	3.53
3	-0.88	0.22	0.79	-2.01	0.94	-0.27
4	-0.73	0.22	0.66	-3.48	0.53	-3.32
5	-1.14	0.23	0.75	-2.35	0.57	-2.39
6	-0.98	0.23	0.75	-2.39	0.58	-2.54
7	-0.93	0.23	1.04	0.37	1.07	0.45
8	-1.35	0.24	0.79	-1.95	0.64	-1.68
9	-1.14	0.23	0.71	-2.82	0.67	-1.74
10	-1.70	0.25	0.99	-0.01	0.78	-0.74
11	-0.83	0.22	0.69	-3.18	0.53	-3.21
12	-0.58	0.22	0.68	-3.26	0.58	-3.17
13	-0.68	0.22	0.74	-2.60	0.67	-2.21
14	-0.63	0.22	0.67	-3.39	0.56	-3.20
15	2.57	0.29	1.26	1.36	3.58	3.55
16	1.36	0.23	1.49	4.33	2.35	4.20
17	1.36	0.23	1.37	3.38	1.98	3.27
18	1.57	0.23	1.41	3.45	2.32	3.67
19	-0.83	0.22	0.95	-0.42	0.87	-0.69
20	-0.63	0.22	0.95	-0.41	0.83	-1.10
21	2.12	0.26	1.10	0.77	2.37	2.85
22	-0.30	0.22	0.79	-2.07	0.70	-2.35
23	0.35	0.21	0.86	-1.44	0.87	-0.88
24	0.26	0.21	0.90	-1.00	0.89	-0.78
25	0.91	0.22	1.27	2.67	1.63	2.88
26	-0.63	0.22	1.13	1.14	1.17	1.04
27	-0.54	0.22	0.87	-1.24	0.74	-1.81
28	2.57	0.29	1.48	2.35	6.31	5.58
29	-0.88	0.22	0.78	-2.12	0.63	-2.34
30	1.25	0.23	1.67	5.73	3.00	5.92
31	-0.49	0.22	0.81	-1.79	0.71	-2.07
32	-0.25	0.22	0.68	-3.30	0.62	-3.12
33	-0.63	0.22	0.99	-0.01	0.98	-0.08
34	0.58	0.22	0.99	-0.11	0.97	-0.12
35	0.12	0.21	1.11	1.05	1.13	0.96

Table 1. Calculation results with J Metric

Based on the results of the J metrics, students' comprehension abilities can be analyzed by identifying the distribution of each student's answers by identifying the person. The distribution of students' abilities is analyzed using the logit measure, as we know the value of 0.0 is the average logit value as a standard ability student and also the difficulty level of the items. Student 18 has the highest logit score, namely +1.57, but there are 23 students who have not been able to answer items S4, S8, S11, S13, S10, S14, S12 correctly because the item logit value is higher than the student's logit value. . The logit value of 17 other students is still below 0.0, this shows that students' conceptual understanding of the heat propagation material is still low. WMS (Weighted Mean Square): Measures how well items fit the model. Ideal range: 0.5–1.5. UMS (Unweighted Mean Square): Same as WMS, but more sensitive to outliers. Ideal range: 0.5–1.5, Value < 0.5: The model is too "overfit" (the questions are very suitable for the students). Value > 1.5: The model is "misfit" (the questions are not well suited to the students' abilities).

Next, a summary of the overall descriptive data with the help of testing and calculations via the Rasch model is shown in Table 2

SCORE TABLE

Score	Theta	Std. Err
0.00	-5.2093	1.84
1.00	-3.9734	1.02
2.00	-3.2336	0.74
3.00	-2.7803	0.62
4.00	-2.4434	0.55
5.00	-2.1696	0.50
6.00	-1.9351	0.47
7.00	-1.7269	0.44
8.00	-1.5375	0.43
9.00	-1.3617	0.41
10.00	-1.1960	0.40
11.00	-1.0380	0.39
12.00	-0.8855	0.39
13.00	-0.7370	0.38
14.00	-0.5912	0.38
15.00	-0.4469	0.38
16.00	-0.3032	0.38
17.00	-0.1591	0.38
18.00	-0.0137	0.38
19.00	0.1338	0.39
20.00	0.2845	0.39
21.00	0.4391	0.40
22.00	0.5988	0.40
23.00	0.7647	0.41
24.00	0.9381	0.42
25.00	1.1205	0.43
26.00	1.3139	0.45
27.00	1.5208	0.46
28.00	1.7445	0.48
29.00	1.9901	0.51
30.00	2.2650	0.54
31.00	2.5815	0.59
32.00	2.9632	0.65
33.00	3.4633	0.77
34.00	4.2510	1.05
35.00	5.5209	1.85

Table 2. Calculation results using the Rasch model

Column *theta* shows estimated capabilities students based on the Rasch Model, expressed in a logit scale. Mark *theta* low(e.g. -5.2093 for a score of 0) indicates very low ability.Score*theta* high(eg 5.5209 for a score of 35) shows very high ability. Mark *theta* around 0 usually reflects average ability.

DISCUSSION.

From the findings on the J Merik and Rasch models, shows that the majority of students (94%) have a low ability to understand physics concepts, while only a small percentage (6%) have a good ability to understand physics concepts. This indicates the need to take corrective action or a more effective learning approach to increase their understanding of concepts related to heat propagation material. Theta value increases as the raw score increases. This shows that the more questions answered correctly, the higher the estimated student ability. The theta scale covers a range from approximately -5.21 (for a score of 0) to 5.52 (for a score of 35). This means that students' abilities are distributed from very low to very high.

The results of this research show that students' ability to understand the concept of physics can be divided into four groups, namely very high, high, moderate and low. These findings confirm that the use of the J metric and Rasch model can be effective in visualizing students' conceptual understanding abilities in various physics subject matter. The use of J Metrics in analyzing understanding of physics concepts has been proven to help in understanding the distribution of students' abilities and provides a deeper view of learning effectiveness. The results of the Rasch model findings show that there are no students who have a high level of ability to understand physics concepts about motion, because none of them has a logit value that exceeds the standard deviation value of 0.73. The results of previous research conducted by Kurli et al. (2021) also indicated that in three categories two people had low mastery abilities with logit values below the average person logit, eleven people had medium mastery abilities with logit values above the average person logit but still below the standard deviation, and one person has high ability with a logit value above the average person and above the standard deviation value. This emphasizes the importance of identifying standard deviations in person measures to classify students' abilities more accurately. Thus, the findings of Person Measure Show that the use of a standard deviation measure is a useful approach in classifying students' ability to understand concepts in subject matter such as heat propagation. With a better understanding of the distribution of students' abilities, appropriate learning approaches can be implemented to effectively improve their understanding of concepts. Person Fit findings Order Show that students are 16, 17, and 18 has value MNSQ is more than 1.2, which means there is a mismatch between their response pattern and the ideal model, and this is outside the accepted limits. However, in the ZSTD aspect, only 15 students are outside the limit. Apart from that, in terms of Pt Measure Corr, student 07 is also outside the limits, which indicates their response pattern is out of the ordinary. Information regarding unusual response patterns can be seen more clearly through a scalogram, which can help to identify inappropriate response patterns with the ideal model. Thus, these findings show that the Rasch model approach is an effective tool in identifying discrepancies in student response patterns with the ideal model, so that it can help ensure consistency of answers and detect possible cheating in answering questions. The findings show that students 07 and 15 were not careful in working on easy questions, such as number 6, but were able to work on questions that were classified as difficult, which was indicated by their logit values being above. Likewise, student 17 was not able to do the second easy question correctly, namely number 3, but was able to do the difficult question. This analysis indicates that the student was probably not working on the question seriously, or there were other factors involved. influence their performance in answering the test. The results of this research showed that several students were indicated to have cheated during the test. Thus, the use of the J Metric in analyzing the ability to understand concepts needs to be used to determine the level of students' seriousness in answering the test. The Rash model provides useful information in identifying inappropriate answer patterns and detecting potential cheating, so that it can provide a deeper understanding of student performance and the overall quality of test results. From the analysis results, the std. A smaller error indicates a more accurate estimate of ability. Standard errors tend to be larger at extreme scores (0 and 35), because there is less student data at the ends of the distribution. Average Student Ability: Viewed from theta disc jockey middle (e.g. a score of 17 or 18), the average ability is around -0.3032 to -0.0137 logit. Average student ability tends to fall in the theta range of around -0.30 to 0, which corresponds to a raw score in the middle (scores 16–18). This reflects that the majority of students have abilities close to average.

CONCLUSION

The conclusions of this research are:

1. The test has high reliability for both items (0.96) and students (0.89), which shows that this instrument is very good at measuring students' abilities and the level of difficulty of the questions.
2. The Separation Index shows that this test is able to differentiate students into almost 3 ability groups, as well as distinguishing items well.

3. The number of strata for students (4.20) and items (6.90) shows the wide coverage of the instrument to detect various levels of ability and difficulty.
4. The results of the research show that the majority of students have mastered the understanding of physics concepts. The average ability is around -0.3032 to -0.0137 logit or lower than 0.0 logit. Scale *theta* covers a range from approximately -5.21 (for a score of 0) to 5.52 (for a score of 35)

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REFERENCE

1. Krathwohl, D. R. (2002). A Revision of Bloom's Taxonomy: An Overview. *Theory Into Practice*, 41(4), 212-218.
2. Puspitasari, W. D., & Febrinita, F. (2020). Persepsi Mahasiswa tentang Pemahaman Konsep Kinematika Gerak ditinjau dari Kemampuan Berpikir Kritis. *UPEJ Unnes P*Rais, H., & Ferinaldi. (2019). Pengaruh Minat Belajar terhadap Pemahaman Konsep Matematis pada Mata Kuliah Teori Bilangan Mahasiswa Pendidikan Matematika . *Mat-Edukasia*, 4(1), 71-77.
3. Simanjuntak, M. P. (2012). Peningkatan Pemahaman Konsep Fisika Mahasiswa melalui Pendekatan Pembelajaran Pemecahan Masalah Berbasis Video. *Jurnal Pendidikan Fisika*, 1(2), 55-60.
4. Slameto. (2010). *Belajar dan Faktor yang Mempengaruhinya*. Jakarta: Rineka Cipta.
5. Suharyat, Y. (2009). Hubungan antara Sikap, Minat dan Perilaku Manusia. *Jurnal Region*, 1(3), 1-19.
6. Wiguna, D. G. E. S., Marhaeni, M. P. A. N., & Suastra, M. P. P. I. W. (2014). Kontribusi Gaya Kognitif dan Konsep Diri terhadap Pemahaman Konsep IPA Mahasiswa Jurusan S1 PGSD Undiksha." *Jurnal Pendidikan Dasar Ganesha*, 4(1), 1-10.
7. Arikunto, S. (2013). **Dasar-dasar Evaluasi Pendidikan**. Jakarta: Bumi Aksara.
8. Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). **Taxonomy of Educational Objectives: The Classification of Educational Goals**. New York: Longmans, Green.
9. Jannah, S. (2020). **Evaluasi Pembelajaran Fisika: Pendekatan dan Aplikasi dalam Pendidikan**. Yogyakarta: Andi Offset.
10. Mulyasa, E. (2013). **Manajemen Pembelajaran Berbasis Kompetensi**. Bandung: Remaja Rosdakarya.
11. Sudjana, D. (2014). **Dasar-dasar Proses Belajar Mengajar**. Bandung: Sinar Baru Algensindo.
12. Wiggins, G., & McTighe, J. (2005). **Understanding by Design**. Alexandria, VA: Association for Supervision and Curriculum Development.
13. Yamin, M. (2013). **Model Pembelajaran Aktif**. Jakarta: Depdiknas.
14. Pusdiklat Kementerian Pendidikan dan Kebudayaan Republik Indonesia. (2017). **Evaluasi Pembelajaran Fisika di Sekolah**. Jakarta: Pusdiklat.
15. Krathwohl, D. R. (2002). A Revision of Bloom's Taxonomy: An Overview. *Theory Into Practice*, 41(4), 212-218.
16. Puspitasari, W. D., & Febrinita, F. (2020). Persepsi Mahasiswa tentang Pemahaman Konsep Kinematika Gerak ditinjau dari Kemampuan Berpikir Kritis. *UPEJ Unnes P*Rais, H., & Ferinaldi. (2019). Pengaruh Minat Belajar terhadap Pemahaman Konsep Matematis pada Mata Kuliah Teori Bilangan Mahasiswa Pendidikan Matematika . *Mat-Edukasia*, 4(1), 71-77.
17. Simanjuntak, M. P. (2012). Peningkatan Pemahaman Konsep Fisika Mahasiswa melalui Pendekatan Pembelajaran Pemecahan Masalah Berbasis Video. *Jurnal Pendidikan Fisika*, 1(2), 55-60.

18. Slameto. (2010). *Belajar dan Faktor yang Mempengaruhinya*. Jakarta: Rineka Cipta.
19. Suharyat, Y. (2009). Hubungan antara Sikap, Minat dan Perilaku Manusia. *Jurnal Region*, 1(3), 1-19.
20. Wiguna, D. G. E. S., Marhaeni, M. P. A. N., & Suastra, M. P. P. I. W. (2014). Kontribusi Gaya Kognitif dan Konsep Diri terhadap Pemahaman Konsep IPA Mahasiswa Jurusan S1 PGSD Undiksha." *Jurnal Pendidikan Dasar Ganesha*, 4(1), 1-10.