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A Rasch Model Analysis in Measuring students' Critical Thinking Skills in science learning model Problem-Based Learning (PBL) Based on Local Wisdom

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Abstract

One of the skills that students must have in the 21st century is critical thinking skills. The learning model that can develop critical thinking skills is the model of problem-based learning (PBL). The purpose of this study is to measure the critical thinking skills of students in science learning model problem-based learning (PBL) based on local wisdom using the Rasch model. The critical thinking skills test was given to 36 students of class VII A and VII B at SMP Negeri 6 Sungai Penuh. The samples in this study were divided into control and experimental classes selected through the purposive sampling technique. Data collection techniques used tests and observation sheets. The data obtained were analyzed through a quantitative descriptive approach using the help of the Rasch model program with *Winsteps software*. The study results explained that problem-based learning (PBL) of local wisdom can improve critical thinking skills on student learning outcomes with Rasch analysis. The unidimensional value indicates that the test measures one dominant variable, namely students' critical thinking skills, with a raw variance value of 42.3% (good) and a variance value of < 15% in the ideal test category. The results of the item reliability test using *winstep* indicate item reliability and person reliability of 0.44 and 0.45 with a Cronbach's alpha value of 0.91 (reliable). These results indicate that the items on the items are normal and valid in measuring students' critical thinking skills.

1. INTRODUCTION

Indonesia is a developing country, and in line with this various fields need to be optimized, one of which is the field of education. In the 21st century, education is the most important part as a place to improve the quality of human resources (Husain & Kaharu, 2021). The world of education is required to be able to implement 21st-century learning (Rinto et al., 2022). The 21st-century learning system is learning where the curriculum requires schools to change the learning approach (Muliastrini, 2020).

Developments in education can be seen from the government's efforts in improving the curriculum. The independent learning curriculum comes as an answer to the tight competition for human resources globally in the 21st century (Amalia, 2022). The latest essence of the independent curriculum model refers to the local content approach, which is adapted to include cultural elements or the potential of local wisdom of the local area (Nurdeni et al., 2022).

There are many competencies that must be mastered in 21st-century learning. Trilling & Fadel (2012) *Partnership for 21st Century Skills*, some of the competencies that must be mastered are 4C (*Critical thinking, Collaboration, Communication, Creativity*). The ability to think critically or *critically thinking* is one of the 4C competencies of the various competencies needed in the 21st century (Zubaidah, 2018). According to Ramdani (2021), students' critical thinking skills in science learning are needed to connect and understand the content of microscopic and abstract science materials that require good analysis, evaluation, and interpretation of students' minds. In addition, critical thinking skills are important in the learning process because this ability provides opportunities for students to learn through self-discovery, solving problems by connecting some knowledge with real-life concepts (Hariandi et al., 2022).

Critical thinking skills can be obtained by applying an integrative learning model. This is in line with the opinion of Astuti (2019) that the learning model that can develop critical thinking skills is the *problem-based* learning model. This is because the *problem-based learning model* provides problems related to solving real-life problems. (Hadi et al., 2019). This is supported by Avitrananda (2020), that the implementation of a *problem-based learning* model of local wisdom can improve critical thinking skills, because students have prior knowledge about the local wisdom of the area, so that students become active in the learning process and students can think critically.

Based on observations made by researchers at SMP Negeri 6 Sungai Penuh, critical thinking skills are still relatively low, and evaluation questions given to students are still focused on low-level cognitive aspects, not yet oriented to develop students' thinking skills. This is indicated from the data on the learning outcomes of students in class VII A, only 33.3%, as many as 6 students out of 18 students who scored above the KKM in science subjects. The prepared learning tools have used the *problem-based learning* (PBL) model, but the implementation of the *problem-based learning* (PBL) model has not been optimally applied and still uses the lecture method directly so students have difficulty in understanding learning concepts, solving problems, overcoming problems, and communicating them. In addition, science learning has also not optimized the basis of local wisdom in the region or around the school environment so that the application of the concept of the subject matter presented is still general. Another indication revealed by science teachers is that the items of questions have not included critical thinking indicators. The lack of optimization of teachers to develop types of critical thinking evaluation questions causes the ability to think critically less developed.

One of the efforts to improve critical thinking skills at SMP Negeri 6 Sungai Penuh is by applying a problem-based learning (PBL) model based on local wisdom. The local wisdom taken in this study is the making of *lemang kancung beruk*, which is wrapped using a kantung semar (*Nepenthes* sp) which is served at the Kerinci kenduri sko traditional event (Mutiara & Fridayati, 2022). *Lemang Kancung Beruk* was chosen because the process of making lemang is closely related to the science of substances and their changes in class VII junior high school. Furthermore, the Rasch model is an effort to improve the accuracy of measuring critical thinking skills in this study. This study aims to measure the critical thinking skills of students learning science problem-based learning (PBL) based on local wisdom using the *Rasch model.*

The advantages of the Rasch model approach can provide linear measures with equal intervals, find misfit items or outliers, overcome missing data, and produce replicable measurements (Wright & Mok, 2004). These advantages, measurements using Rasch models can produce the same quality measurements in certain fields (Falani et al., 2022). Therefore, the measurement of critical thinking skills with the PBL model is based on local wisdom using the Rasch model.

2. METHOD

Participants

The participants in this study consisted of 36 students from class VII of SMP Negeri 6 Sungai Penuh. There are 18 students in class VII A, 9 boys and 7 girls. Class VII B amounted to 18 students, there were 7 boys and 9 girls. The sample used in this study was obtained using *a purposive sampling* technique to determine class A as the control class and class B as the experimental class. This type of research is quasi-experimental research and data collection techniques using critical thinking tests and observation sheets. The science material in this study used is the material Substance and its Changes in Class VII junior high school odd semester.

Critical Thinking Indicators

Indicators as a critical thinking measurement instrument aim as a tool to measure and guide critical thinking. According to the theory of Ennis (2011), critical thinking indicators are classified into five parts, which are abbreviated as FRISCO: F *(Focus*), R (*Reason*), I (*Inference),* S (*Situation),* C (*Clarity),* O (*Overview)* in table 1.

Table 1. Aspects and Indicators of Critical Thinking

No	Aspects of Critical Thinking	Critical Thinking Indicators
1	F (*Focus)*	1. Focusing on the question or issue 2. Understand, and identify information and problems
2	R (*Reason*)	1. Analyzing arguments 2. Express an opinion based on relevant facts or evidence
3	I *(Inference*)	1. Make a reasoned or convincing conclusion 2. Determine the appropriate reasoning to support the conclusion made
4	S (*Situation)*	1. Understand the situation in thinking to help clarify questions or know the meaning of key terms. 2. Use information that is relevant to the problem.
5	C (*Clarity*)	1. Able to provide further explanation of the conclusions that have been made, can explain existing terms 2. Can communicate examples of problems that are similar to the given problem.
6	O (*Overview*)	1. Thoroughly review, check, or re-correct the results of problem-solving

Source: (Ennis, 2011)

Rasch Model

George Rasch introduced the Rasch model in 1960. This probabilistic model was revolutionary in the field of psychometrics. The *Rasch model* is a modern assessment theory that can classify item and person calculations in a distribution map (Rozeha et al., 2007). It is believed to improve the measurement accuracy of variables. Therefore, the Rasch *Model* was used in this study to test the validity and reliability of the ideal instrument. The advantage of *Rasch* modeling is the ability to predict missing data, which is based on the head of a systematic response pattern (Aziz, 2015). This study utilizes the *Rating Scale Model* as the *Rasch* RSM *model* (Andrich & Marais, 2019). RSM is an item response theory model with the following mathematical equation:

$$P\ (X_{\text{vi}} = h) = \frac{\exp\ (h(\theta v + \beta i) + \omega h}{\sum_{l=0}^{k} \exp\ (l(\theta v + \beta i) + \omega l} \quad (1)$$

Description:
X: an ordinal items data matrix of size nxm
K: items that have the same category
P(X): the probability that a v test taker will receive an h score on item i
θv: the test taker parameter
βi: the item's location parameter
h: symbolized by the ωi parameter which is constant across items

Statistical Analysis

Data from the test results of students' critical thinking skills were analyzed using the *Rasch Model*. *Rasch* analysis was carried out using *Winsteps* Version 4.8.2.0 *software*. The data analysis that was tested was the assumption of *dimensionality, item fit, and reliability*. The unidimensionality test uses criteria based on the raw variance explanation value. With conditions >20% (met), >40% (good), and >60% (excellent). Item fit explains whether the items function normally and are valid in measuring critical thinking skills. The item fit criteria used are outfit mean square (MNSQ) with an acceptable value in the interval 0.5 < MNSQ < 1.5, outfit Z-standard (ZSTD) in the interval -2 < ZSTD < 2, and point measure correlation (Pt Mean Corr) in the interval 0.4 to 0.85. The criteria for an item to show bias is if the probability value is less than 0.05 or <5% (Sumintono & Widhiarso, 2015)

3. RESULTS AND DISCUSSION

Dimensionality

The unidimensionality assumption test is used to evaluate whether the test measures one dimension, namely students' critical thinking ability. This is done with the *Rasch model* which uses principal component analysis of the residuals. The measurement model of the critical thinking test proved to be unidimensional as shown in Table 2. The *raw variance* value that can be explained by the measurement is 42.3% and has exceeded the minimum criteria of more than 20% (met), 40% (good), and 60% (excellent). In addition, the variance that cannot be explained by the instrument does not exceed 15%. Therefore, it can be categorized as an ideal test.

Table 2. The variance of standardized residuals

Standardized residual variance	Items informations units	
	Eigenvalue	**Observed**
Total raw variance in observations	10.3969	100.0%
Raw variance explained by measured	4.3969	42.3%
Raw variance explained by persons	2.7222	26.2%
Raw variance explained by items	1.6747	16.1%
Raw unexplained variance (total)	6.0000	57.7%
Unexplained variance in 1st contrast	1.7524	16.9%
Unexplained variance in 2nd contrast	1.3392	12.9%
Unexplained variance in 3rd contrast	1.1375	10.9%
Unexplained variance in 4th contrast	1.0059	9.7%
Unexplained variance in 5th contrast	0.7300	7.0%

Items Fit

Item fit describes the function of the item in measurement. Misconceptions in respondents about an item are identified as unfitting. The MNSQ outfit value range of 0.5 to 1.5, the Z-standard outfit (ZSTD) in the interval -2 < ZSTD < 2, and the point measure correlation (Pt Mean Corr) in the interval 0.4 to 0.85 are criteria that can be used to determine the level of fit.

From the MNSQ, ZSTD, and Pt Mean Corr columns, it can be seen that all critical thinking ability test items have MNSQ values between 0.37 to 2.18 on item number 1 (2.18), number 2 (1.56), and number 6 (0.37) so that item numbers 3, 4 and 5 are in the range of 0.5 to 1.5. The ZSTD value of all items is between -2 < ZSTD < 2 and the Pt Mean Corr value on all items is between 0.90 to 0.79 on item number 4 which is 0.86 and item number 6 which is 0.90, while item numbers 1,2,3 and 5 are at Pt Mean Corr values between 0.4 to 0.85. Based on the available evidence, it is confirmed that the items and categories of the critical thinking ability test are functioning properly as seen from the category that fulfills one of the item's fit criteria and even all three items fit the criteria in Table 3. Therefore, this item has a decent quality to collect data about students' critical thinking skills

Reliabiliy

In the Rasch Model, reliabilities were estimated for both items and persons, as presented in Table 4. Statistical analysis Item numbers are automatically sorted by difficulty in Table 3. This ordering is based on the *Items Measure* column value with logit units. The higher the logit value, the greater the difficulty level of the question. Finally, the score column shows the number of correct answers given by respondents. This logit calculation algorithm uses odd ratio probability and logit transformation which is believed to improve measurement accuracy. The reliability of the critical thinking test is 0.44 at the personal level. This shows that the respondents' answers are consistent. Therefore, the person's reliability value is in the very good range. Part of the respondents about the item when a question is identified as inappropriate.

The range of MNSQ outfit values of 0.5 to 1.5 is a criterion that can be used to determine the level of item suitability. Table 5 indicates the reliability of the critical thinking ability test items is 0.45. This shows the consistency of the item/instrument in distinguishing people on the variable being measured (critical thinking ability). This further indicates that the value falls into the "special" category. The *Cronbach's Alpha* value was also obtained which shows the reliability of the interaction between people and items as a whole which is 0.91 and falls into the "very good" *reliable* category.

Table 3. Items fit summary

Entry No	Total Score	Total Count	Measure	Model S.E	OUTFIT		Pt Mean Corr
					MNSQ	*ZSTD*	
1	19	36	-1.39	0.71	2.18	1.35	0.79
2	16	36	-0.07	0.63	1.56	1.20	0.78
3	18	36	-0.92	0.68	1.30	0.64	0.86
4	14	36	0.68	0.60	0.66	-0.66	0.84
5	12	36	1.38	0.59	0.58	-0.52	0.81
6	15	36	0.32	0.61	0.37	-1.74	0.90

Z.E.: standard error; MNSQ: mean-square or standardized fit statistics; ZSTD: value of Z standard.

Table 4. Person reliability

	Total Score	Total Count	Measure	Model S.E	INFIT		OUTFIT	
					MNSQ	*ZSTD*	*MNSQ*	*ZSTD*
Mean	3.4	6.0	0.37	1.08	0.98	0.03	1.11	0.15
P.SD	1.7	0.0	1.57	0.10	0.36	0.76	1.07	0.85
S.SD	1.7	0.0	1.62	0.11	0.37	0.79	1.10	0.88
Max	5.0	6.0	1.87	1.15	1.55	0.97	4.57	2.09
Min	1.0	6.0	-1.87	0.90	0.55	-1.45	0.40	-1.34

Real RMSE 1.17, True SD 1.04, Separation 0.89, Person Reliability 0.44. Model RMSE 1.09, True SD 1.13, Separation 1.04, Person Reliability 0.52, S.E. of Person Mean = 0.39

Person raw score-to-measure correlation = 1.00. Cronbach alpha (KR-20) person raw score “test” reliability =0.91 sem = 0.73. S.E.: standard error; SD: standard deviation; P.SD: population standard deviation; S.SD: sample standard deviation; RMSE: root mean square error; MNSQ: mean-square or standardized fit statistics; ZSTD: value of Z standard.

Table 5. Items reliability

	Total Score	Total Count	Measure	Model S.E	INFIT		OUTFIT	
					MNSQ	*ZSTD*	*MNSQ*	*ZSTD*
Mean	15.7	36.0	0.00	0.64	0.99	-1.15	1.11	0.05
P.SD	2.4	0.0	0.94	0.04	0.37	1.12	0.63	1.11
S.SD	2.6	0.0	1.02	0.05	0.40	1.22	0.69	1.22
Max	19.0	36.0	1.38	0.71	1.53	1.35	2.18	1.35
Min	12.0	36.0	-1.39	0.59	0.49	-1.82	0.37	-1.74

Real RMSE 0.69, True SD 0.63, Separation 0.91 Item Reliability 0.45. Model RMSE 0.64, True SD 0.68, Separation 1.07, Item Reliability 0.53, S.E. of Item Mean = 0.42

S.E.: standard error; SD: standard deviation; P.SD: population standard deviation; S.SD: sample standard deviation; RMSE: root mean square error; MNSQ: mean-square or standardized fit statistics; ZSTD: the value of Z standard

Wright Map

Wright's map is one of the hallmarks of the Rasch Model. According to Wang and Wilson, it shows the relationship between the level of a person's "latent trait" and also the "difficulty" of directly comparable items (Wang & Wilson, 2005). Figure 1 shows the Wright Map of the results of the analysis of students' critical thinking skills. The Wright map on the left illustrates the ability of the respondents. It is observed that 6 respondents have a high ability higher than the difficulty level of the question, this illustrates that they can easily answer the given statement items. While 13 respondents have low ability which indicates that they have difficulty answering the test items given.

The right map shows the difficulty level of the items. The most challenging answer for respondents is item QR, while the easiest is QF. By comparing respondents' ability and item difficulty, Wright's map shows that the average item logit value of 0.0 logit is lower than the average person logit of 0.37. This shows that the typical student's overall critical thinking test answering is above the average test difficulty level.

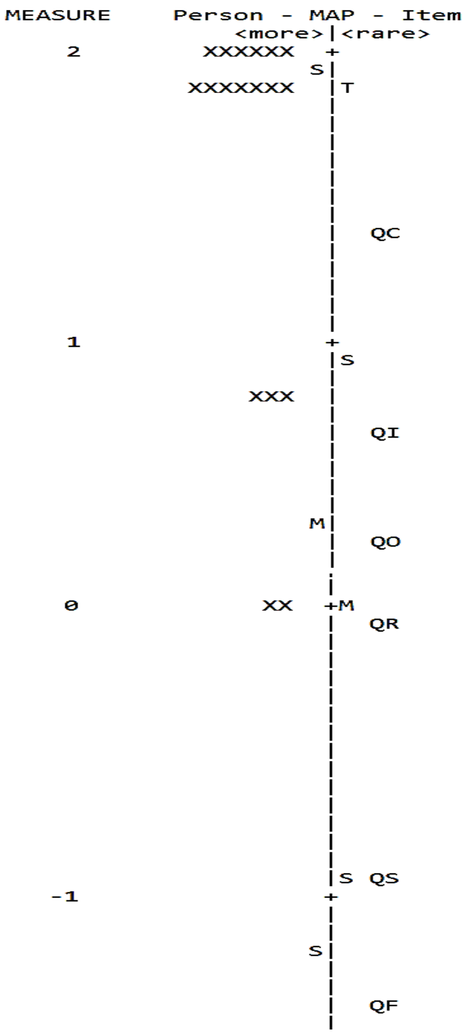
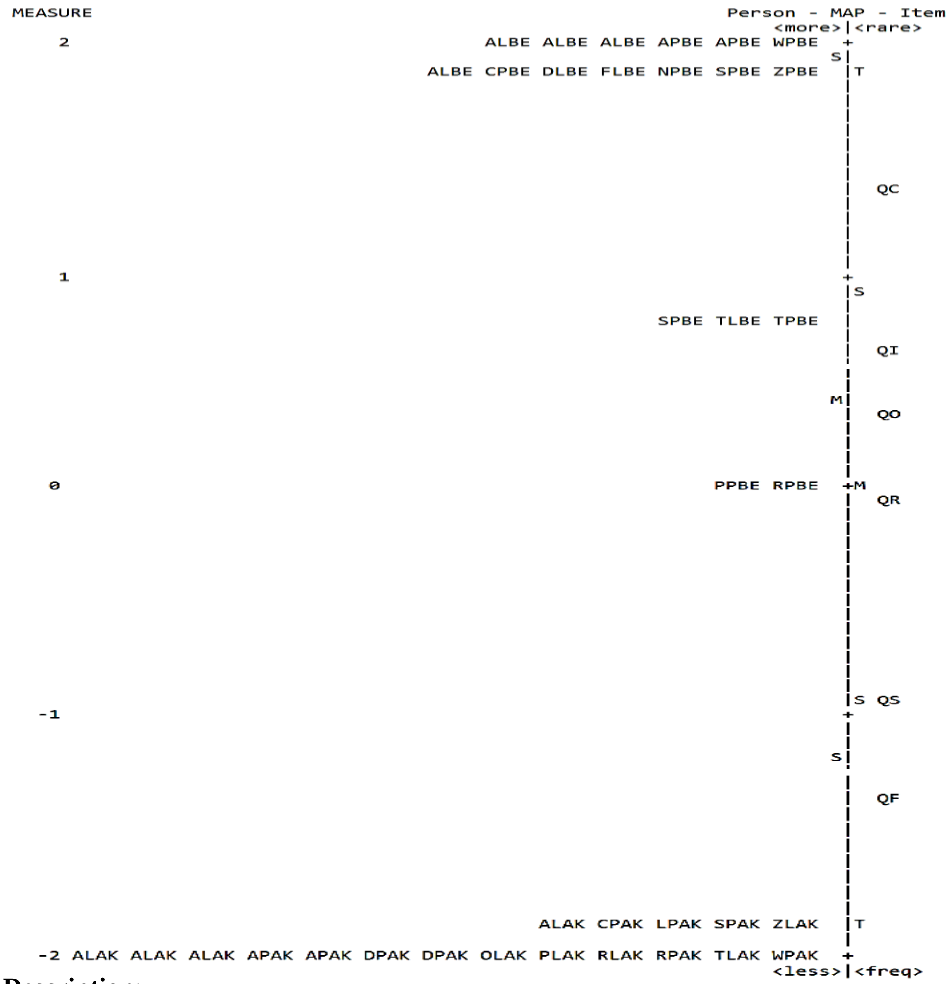


Figure 1. Wright map

In Figure II, based on the person code, the average person of the experimental class has a higher level of critical thinking ability than the difficulty level of the question, and the average person code of the control class has a lower critical thinking ability than the critical thinking indicator question given. This shows that the class treatment in the form of applying a learning model-*based learning model* (PBL) based on local wisdom has an influence on increasing students' critical thinking skills compared to the control class without a model-*based learning model* (PBL) based on local wisdom.



Description:
A/B/D etc (First letter initials), P/L (Gender), A/B (Class), K/E (Control/Experiment)

Figure 2. Wright map of person code

4. CONCLUSION

Based on the results of the psychometric analysis of the test/instrument in measuring students' critical thinking skills, it is concluded that the test meets the criteria of validity and reliability. Therefore, this test can be considered appropriate and recommended to measure students' critical thinking skills in the local wisdom-based problem-based learning science learning model. Future research can use other modern test theory approaches, such as item response theory, to evaluate the psychometrics of the questionnaire to improve measurement accuracy in learning.

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