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Survey of Rasch Model Analysis of Mathematical Literacy Abilities of Senior High School Students

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ABSTRACT

Mathematical literacy skills are needed in everyday life, but the mathematical literacy skills of students in schools show that Indonesian students are very low in the field of mathematical literacy. Therefore, this study aims to determine the Rasch model analysis survey of mathematical literacy skills of senior high school students. This study uses quantitative research methods with a survey approach and uses the Rasch model as a measurement. The subjects studied were 100 students consisting of grades X and XI of high schools in Bekasi city. Furthermore, the results of this study indicate that there is 1 out of 8 items that are misfit and for the provisional calculation of reliability is 0.42, so it is declared not reliable and for the DIF test results there is only one item that is biased.

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1. INTRODUCTION

Mathematical literacy skills is an ability possessed by a person that is used to formulate, apply, and interpret mathematics in solving problems related to oneself, society and the environment. Therefore, in life, mathematical literacy skills are needed to guide students to solve every problem that exists[1]–[3] . In the PISA (Programme for International Student Assessment) carried out in 2022 proved that Indonesia was ranked 68 out of 81 participating countries, the results of this fact show that Indonesian students are very low in the field of mathematics literacy [4][5]. Mathematical literacy skills are important for students' success in learning because they can help students in everyday life such as analyzing, giving reasons and communicating and explaining ideas effectively on a problem [6][7]. So, to develop mathematical literacy skills in students can provide questions that contain students' mathematical literacy skills.

Development questions of mathematical literacy skills can be done by testing the validity and reliability of the usual test using the Rasch model. Rasch Model is a modern assessment that is able to classify item and person calculations on distribution maps. The Rasch Model was used to evaluate and determine the validity and reliability of the questionnaire using WinSteps software and the validity and reliability of Cronbach's Alpha [8], Rasch models are capable of addressing the issue of missing data, providing accurate estimates, generating linear measures with equal intervals, and developing measurement instruments that are independent of the parameters of interest [9]. So many researchers use the winsteps application for Rasch model measurement. The advantages of the Rasch model for validity and reliability calculations are scores that describe the ability of participants and do not depend on the level of difficulty of the test, can be used to link items to the ability of participants, and the reliability coefficient is not contingent upon the implementation of parallel tests. [9].

Based on research conducted by Atikah, Sudiyatno, Rahim and Marlina (2022) [9] related to the assessment of mathematics final test questions in junior high school using the Rasch model. The results showed the estimation of item validity fit is obtained from the quality of the final mathematics test, conducted using the Rasch model., where from 40 questions that were examined had an INFIT MNSQ (Mean Square) value between 0.94-1.11, and questions with an OUTFIT t score obtained ÿ 2.00. Then questions with three items in the difficult category were 7.5%, the medium item category was 20 items with a percentage of 50%, the easy category was 17 items with a percentage of 42.5%, and in the very easy category was 0% of the items. The reliability estimate value is obtained at 0.00 with a medium category, and the items in question are situated within the very high reliability category, with an estimated reliability value of 0.85.

Based on research conducted by Putra, Hermita, and Alim (2021) [10] related to analysis using Rasch model on mathematics knowledge, technology and didactics of prospective elementary school teachers. The results showed that for mathematics knowledge according to the answers of prospective teacher respondents were weak because the person reliability value was 0.44 while the item reliability was 0.94. Then for didactic knowledge, respondents have a low ability to answer questions because the person reliability value is 0.55 while the item reliability is 0.94. And for technological knowledge, respondents tend to answer questions given below the middle value, because the person reliability value is 0.72 and the item reliability is 0.94. For the knowledge of mathematics, didactics and technology, prospective teachers are in the sufficient category.

Based on research conducted by Agustiani and Marlena (2023) [11] related to measuring the mathematical literacy skills of senior high school students based on adversity quotient categories with rasch model data analysis techniques in Bogor city. The results of the study stated that the Rasch model results showed a person measure of -0.30 logit which explained that respondents tended to disagree with AQ (Adversity Quotient) items, where the person reliability value was 0.79 which explained the consistency of respondents when answering AQ was quite good, then the Cronbach Alpha value was 0.71 which explained the interaction between respondents and good items.

Based on research conducted by Yunika, Rohmah, Istiqomah and Faradillah (2021) [8] related to the validity and reliability test of anxiety questioner using Rasch model in learning mathematics. The results of the study based on Rasch, 17 numbers are not suitable to meet the criteria, meanwhile, there are six items that meet the specified criteria, and three other items (I1, I9, and I6) meet at least one criterion and must be maintained. The items matched for 85 (71%) respondents where quality results for assessment using Rasch

analysis, while the other 31 (29%) respondents were not readable in the winsteps application, causing the data to be misfit. From the fit data, there were 43 vocational students, 26 high school students, 16 junior high school students.

According to several studies conducted, not many have examined the Rasch model analysis of students' mathematical literacy skills. Therefore, researchers want to examine further about it which aims to find out the survey of Rasch model analysis of mathematical literacy skills of upper secondary students. As for the formulation of the problem, how are the results of Rasch model analysis of mathematical literacy skills in upper secondary students?

2. RESEARCH METHODS

2.1 Research Design and Participants

In this study, researchers used quantitative research methods with a survey approach. According to Sa'adah in 2020 [12] survey approach research is research with samples taken from a population and using questionnaire techniques used as the main data collection tool. This is in line with the opinion of Harisman, Yulyanti Taufik, Iqbal Suherman, Suherman Resmi, Darni Noto, Muchamad Subali in 2022. [13] said that the purpose of the survey approach is to summarize and describe various situations and conditions or many variables found at the research site.

The technique used in selecting subjects is purposive sampling. Purposive sampling is one of the techniques that takes the subject by deliberately in accordance with the requirements and criteria given [14].

Table 1. Participants

No	Demographics	Description	Code	Quantity
1	Class	X	X	32
		XI	Y	68
2	Age	15	A	13
		16	B	48
		17	C	32
3	Gender	Female	P	59
		Male	L	41

Table 1. Provides information about respondents grouped by class, age, and gender. Class groups were coded X for grade 10 and Y for grade XI. The age group used codes A, B, and C for ages 15, 16, and 17. The gender group used the code P for female and L for male. With the total number of respondents is 100 respondents.

2.2 Instrument

In this study the researchers used instruments based on indicators of mathematical literacy skills. The indicators are.

Table 2. Instrument

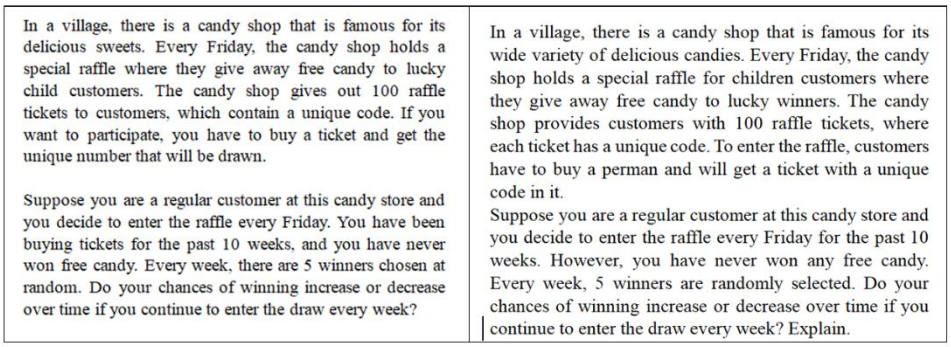
No	Indicator Aspect Mathematical Literacy Skills	Description	Scoring	Score
1	Comprehension Aspect	Students are able to understand each information, describe mathematics to	1. Students have not shown an understanding of the mathematical information and concepts contained in the problem. 2. Students have not been able to explain in detail related mathematical information and concepts. 3. Students have not been able to use mathematical symbols and notations.	0

No	Indicator Aspect Mathematical Literacy Skills	Description	Scoring	Score
		various conditions	4. Students have not been able to describe the steps of problem solving clearly and in detail	
			1. Students have a lack of understanding of the mathematical information and concepts contained in the problem. 2. Students are not able to explain clearly the mathematical information and concepts. 3. Students have not been able to use mathematical symbols and notations correctly. 4. Students have not been able to describe logically and systematically the steps of problem solving.	1
			1. Students demonstrate a thorough understanding of the mathematical information and concepts presented in the task. 2. Students are able to explain mathematical information and concepts clearly and accurately in formal language. 3. Students will be able to use mathematical symbols and notation correctly. 4. Students are able to explain logically and systematically the steps of solving a problem.	2
			1. Students demonstrate a thorough understanding of the mathematical information and concepts presented in the task. 2. Students are able to explain mathematical information and concepts clearly and accurately in formal language. 3. Students are able to use mathematical symbols and notations appropriately. 4. Students are able to explain the steps of solving a problem in a logical, systematic, and structured manner.	3
2	Aspect Analysis	Students are able to convert important information into mathematical form	1. Students are unable to analyse the information in the question accurately. 2. Students are unable to distribute or organise information into smaller elements. 3. Students are unable to recognise patterns and relationships between information components. 4. Students are unable to identify or formulate questions contained in the problem.	0
			1. A small number of students carefully analyse the information in the problem. 2. Students are less able to distribute information into smaller elements. 3. Students do not clearly understand the patterns and relationships between information components. 4. Students identify or formulate questions in a problem that are less relevant or important to solving the problem.	1
			1. Most students analyse the information in the question carefully. 2. Students distribute the information into smaller components fairly well. 3. Students recognise patterns and relationships between information components very clearly. 4. Students identify or formulate important questions related to problem solving.	2
			1. Students clearly analyse all the information in the question. 2. The student appropriately distributes/organises the information into smaller, relevant components. 3. Students are highly able to identify patterns and relationships between information components.	3

No	Indicator Aspect Mathematical Literacy Skills	Description	Scoring	Score
			4. The student correctly identifies or formulates questions in the problem that are relevant and important for solving it.	
3	Aspects of Representation	Students are able to analyse each piece of information, organising it into smaller parts.	1. Students have not been able to transform significant information into various mathematical forms.	0
			1. Students are rarely able to transform significant information into various mathematical forms appropriately and accurately. 2. Students have difficulty in using various mathematical forms, and the transformations made may be less effective and less clear.	1
			1. Students can generally transform significant information into various mathematical forms precisely and accurately. 2. Students can use two kinds of mathematical forms, but there are still errors in transformation.	2
			1. Students are able to transform significant information into various mathematical forms appropriately and accurately. 2. Students can use three kinds of mathematical forms, such as equations, tables, graphs and diagrams, to represent information clearly and effectively.	3
4	Communication Aspects	Students are able to argue and solve problems	1. Students can only explain the solution illogically or incorrectly. Argumentation is not easy to understand. 2. Students have not been able to solve the problem correctly. The strategy used is inappropriate and ineffective. The solution is incomplete or inaccurate.	0
			1. Students can explain the solution clearly, but not precisely. Argumentation is not easy to understand and not supported by evidence. 2. Students can explain the problem quite precisely, but less efficiently. The strategy used is inappropriate or ineffective. The solution is incomplete or inaccurate.	1
			1. Students can explain the problem quite clearly and logically. Argumentation can be understood with some effort. 2. Students are able to explain the solution quite clearly and logically. Argumentation can be understood with some effort.	2
			1. The student can explain the opinion quite clearly and logically. Argumentation can be understood with some effort. 2. Students can solve the problem correctly and efficiently. The strategy used is appropriate and effective. The solution is complete and accurate.	3

Data source: [15]

Table 2 is a Table of indicators used as a reference for instruments that have been tested. Furthermore, the instrument went through a validation stage carried out by two experts, namely a lecturer in Mathematics Education and a mathematics teacher. This instrument has gone through several content validation processes. The purpose of content validation is to measure and know the mathematical literacy test questions are in accordance with the indicators of mathematical literacy skills achieved [16]. The results of the validation are.



(a) **(b)**

Figure 1. (a) Question B1 (Before validation); (b) Question B2 (After validation)

The questions from several questions used for instrument validation examinations in different high schools are displayed in the image above. The question (B1) displays the question that has not been validated, and the question (B2) displays the question that has been validated by two experts in the field of validation. The results of the validation show improvements in word composition and a shift from routine to non-routine problems by substituting different numbers for integers.

3. RESULTS AND DISCUSSION

3.1 Validity

Before the item fit test is carried out, the person fit test is carried out first. Person fit is a method that has a function to see and measure the relationship between the test model and the participant's response. [17]. In conducting the person and item fit tests, researchers distributed questions to 100 students with an instrument of 8 items. Item fit is used as a mapping to determine the cause of items falling into low criteria. [18]. If the results obtained show that there are items that do not meet the MNSQ Outfit, ZSTD Outfit and PT. MEASURE-CORR criteria, with at least two criteria met, the item is said to be unfit and requires the item to be removed or replaced [19]. The following is a Table of results for person and item fit.

Table 3. Person Fit

Num	Respondent	Outfit MNSQ (0,5 < x < 1,5)	Outfit ZSTD (-2,0 < x < 2.0)	PT.MEASURE-CORR (0,4 < x < 0,85)
1.	002BLX	1.51	1.2	0.20
2.	041BPX	1.62	1.7	0.01
3.	047BLX	1.74	1.3	0.16
4.	070APX	1.55	1.4	-0.16
5.	073DLY	1.58	1.6	-0.40
6.	075BLY	1.53	1.5	-0.33
7.	081ALY	1.52	1.4	-0.31
8.	094CPY	1.81	1.2	-0.03
9.	097ALY	1.70	1.7	-0.35
10.	098APX	1.52	1.4	-0.31

Table 3 shows the results of all persons who did not fit the Rasch Model analysis. In testing the data, only 70 data are visible and legible, meaning only 70% of the 100 persons. The data was then analyzed and proved that there were 10 invalid persons and for the valid ones showed 60 persons with a minimum of meeting two criteria between MNSQ Outfit, ZSTD (Z-Standard) Outfit and PT MEASURE-CORR. The results of the person fit test resulted that there were 60 respondents only who had the quality to be used as an assessment with the Rasch model analysis test.

Table 4. Item fit

Item instrument	1	2	3	4	5	6	7	8
Outfit MNSQ (0,5 > x < 1,5)	0,83	0,75	1,51	0,84	0,96	0,94	1,04	1,10

Item instrument	1	2	3	4	5	6	7	8
Outfit ZSTD (-2,0 > x < 2.0)	-1.1	-1,7	3,5	-1,4	-0,2	-0,3	0,3	0,7
PT.MEASURE-CORR (0,4 > x < 0,85)	0,42	0,43	0,35	0,50	0,49	0,37	0,41	0,43

Table 4 states the results of Outfit MNSQ, Outfit ZSTD and PT.MEASURE-CORR. The range of values used as a guide to determine the results, Outfit MNSQ (0.5 < x < 1.5); Outfit ZSTD (-2.0 < x < 2.0); PT.MEASURE-CORR (0.4 < x < 0.85). There is one item that is declared misfit or not fit, as evidenced by the results of values that are not included in the MNSQ Outfit, ZSTD Outfit and PT.MEASURE-CORR categories, namely question number 3. Followed by question number 6 which only meets the MNSQ Outfit criteria and not for ZSTD Outfit and PT.MEASURE-CORE, it can be said to be fit and retained. For the remaining items 1,2,4,5,7 and 8 fulfil all the criteria and it is concluded that the results are fit.

3.2 Reliability

The reliability of an instrument and respondents can be known whether it is reliable or not with a reliability test. Reliability is a tool to measure a test can be consistent even though it has been retested continuously with conditions and subjects do not change [20]. So, reliability can also be referred to as the consistency of the instrument. To determine reliability, can use Winsteps software and then select summary statistics. The criteria used as a reference are Cronbach's alpha (KR-20) with a criterion range of > 0.50, Item and Person Reliability with good criteria, 0.81-0.90; very good, 0.91-0.94; excellent, >0.94) [20]. The following figure presents the results of the reliability test using Winsteps.

Table 5. Output Summary Statistic (Winsteps)

Statistics	Value
Person Reliability	0.46
Person Separation	0.93
Item Reliability	0.87
Item Separation	2.58
Cronbach Alpha (KR-20)	0.42

Table 5 contains quality question and respondent information. There is also information on the relationship between questions and respondents. To see the results of the respondents, you can see the mean section with the measure, showing a number of -0.66. Person reliability shows the reliability of the respondent, 0.46 is the result of the researcher's data. Furthermore, see item reliability with a result of 0.87 and the last part of Cronbach alpha, which is 0.42. So, it can be concluded that the items used are not reliable.

3.3 DIF (Differential Item Functioning)

DIF is needed to test each item there is no element of ambiguity or bias and all individuals are equal, no one is superior, this is if the value of the probability for the item < 5% (p < 0.05). In analyzing the items in the DIF test, several criteria are given as benchmarks for calculating it, for the DIF contrast results the contrast must exceed 0.5 (>0.5) and the value for the probability must be smaller than 0.05 (<0.05). [21].

Table 6. DIF(Differential Item Functioning)

No	status	DIF Measure	DIF Contrast	T	Probability
I1	A	1.38	-1.25	-0.92	0.4142
	B	0.13	1.25	0.92	
I2	A	0.41	-0.19	-0.15	0.6171
	B	0.22	0.19	0.15	
I3	A	-0.91	0.07	0.04	0.2207
	B	-0.84	-0.07	-0.04	
I4	A	0.27	-0.82	-0.62	1.0000
	B	-0.55	0.82	0.62	
I5	A	-0.60	0.73	0.50	0.4142
	B	0.13	-0.73	-0.50	
I6	A	1.43	-1.01	-0.72	0.1088

No	status	DIF Measure	DIF Contrast	T	Probability
I7	B	0.42	1.01	0.72	0.2850
	A	-0.57	0.90	0.63	
	B	0.33	-0.90	-0.63	
I8	A	-0.60	0.73	0.50	0.0000
	B	0.13	-0,73	-0.50	

Table 6. contains the results of the DIF test. After observing and analysing there are items that do not fall into the categories provided. After analysis, all items fall into the category of unbiased and unambiguous items.

4. CONCLUSIONS

Based on Rasch analysis, the results of the person fit test indicate that there are only 60 respondents who have the quality to be used as an assessment with the Rasch model analysis test. The results of the mean respondent with measure, showed a number of -0.66. then person reliability shows the reliability of the respondent, 0.46 is the result of the researcher's data. Furthermore, see item reliability with a result of 0.87 and the last part of Cronbach alpha which is 0.42. Therefore, it can be concluded that the items used are not reliable. And the DIF test results state that all items fall into the category of questions that are not ambiguous.

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