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How does Rasch Modelling Reveal Difficulty and Suitability Level of the Fraction Test Question?

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Abstrak

Penting mengetahui informasi yang lengkap tentang alat pengukuran kemampuan yang dimanfaatkan untuk mengetahui besar kecilnya hasil belajar dari peserta didik. Berikut ditunjukkan bagaimana menganalisis soal berikut pengelompokkan tingkat kesukaran dan kesesuaian item soal tes; khususnya pada materi bilangan pecahan di sekolah dasar. Proses analisis dilakukan dengan pemodelan rasch menggunakan aplikasi winsteps 3.75; serta kombinasi dari nilai standard deviasi (SD) dan nilai rata-rata logit (Mean). Diperlukan soal yang valid dan hasil pengisian soal tes, kemudian dilakukan proses pengolahan dan analisis data. Kemudian data skor per orang dan data skor dari setiap *item,*digunakan untuk mengestimasi skor murni dalam satuan logit yang dapat menunjukkan tingkatan kesukaran dari butir soal. Tingkat kesukaran butir soal ditentukan dengan pengelompokkan kategori soal sukar dengan nilai logit lebih besar +1SD; soal sangat sukar 0,0 logit +1 SD; soal mudah 0,0 logit -1 SD; soal sangat mudah dengan nilai lebih kecil dari –SD. Terdapat tiga criteria penentuan tingka tkesukaran dan kesesuaian soal dengan nilai *Outfit Z- Standard/ZSTD; Outfit Mean Square/MNSQ; & Point Measer Correlation*.Penelitian ini, menghasilkan kumpulan soal tes bilangan pecahan dengan kategori layak digunakan berikut ragam tingka tkesukaran.Implikasi kepada para peneliti atau guru, dapat membantu mengidentifikasi berbagai kemampuan siswa secara detail.

Kata kunci: Analisis Kesukaran dan Kesesuaian Item, Soal Tes Bilangan Pecahan, Model Rasch

Abstract

It is important knowing information about the measurement tools used to find out how learning outcomes are shown by students. This research show how to analyze the questions which grouping the difficulty and suitability level of test items; especially of fractions in elementary school. The analysis process is carried out through Raschmodeling assisted by the Winsteps 3.75 application, combination of the standard deviation (SD) and logit mean values (Mean). Valid questions and result after filling out the questions test are needed, then processing and analyzing the data. Then, the data per person is used to indicate in logit units which show the various items. Determination of the dificulty level of the items, grouping with difficult questions with a logit value greater than +1 SD; very difficult with 0.0 logit +1 SD; easy with 0.0 logit -1 SD; very easy less than –SD. There are three criteria for determining the level of difficulty and suitability of the questions with the Outfit Z-Standard/ZSTD value; Outfit Mean Square/MNSQ; & Point Measer Correlation. This research collected of valid test question of fractions material with various level of difficulty. Implications for researchers or teachers, can help identify the various abilities of students in detail.

Keywords: Difficulty Analysis and Item Fitness, Fractions Test Questions, Rasch Modeling

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Introduction

Every learning process has goal related to some knowledge or skills that must be obtained by students. In the process of achieving the goal, a measurement is used to determine the value, score, or percentage achieved by students related to the learning objectives. In the process or end of learning, it is necessary to measure the learning process and its results in the form of numbers that reflect the achievements of the learning process and results. According to Mardapi, measurement is basically an activity of determining numbers on an object systematically (Doran, R. L., 1980). Measurement is a process or activity to determine the quantity of something. The word "something" could mean students, teachers, school buildings, study tables, whiteboards, and so on (Parker, C., 2000). Measurement is a process that describes performance of student with quantitative scale till qualitative characteristic is shown by numbers(Alwasilah et. Al., 1996). Thus, measurement in education means measuring student attributes or characteristics (Goddard et. al., 2000).

Measurement in education is closely related to tests. This is because one way that is often used to measure the results that have been achieved by students is by testing (Harris, L. R. and Brown G. T., 2010). In the measurement process, the teacher must use either test or non-test measurement tools (Parker, C., 2000). According to Zainul, the test is defined as a question or task or a set of tasks that are used to obtain information about an educational attribute. The test used is adjusted to the subject or field of science that will be used as a test source (Zainul,A., 2001).

The results obtained from the test are data. In this article, the data will be analyzed whish used the Winsteps 3.75 application through Rasch model of rating scale. The Rasch Model is a measurement approach that lernt nicely which made the relationship model between item difficulty, person ability, and the probability of response given(Andrich, D.. 1981). The Rasch model can be used by teachers for developing item test and also important tool with psychometric analysis techniques that can give relevant information related of assessment for student leaning (Sumintono, B., 2018). The analysis of instrument tests that using rasch model include in respons utem measurement theory. This measurement describes of interaction between subject and test items. It will make the result of measurement more appropriate and objective (Sumintono, B. andWidhiarso, W., 2014). Meanwhile according to Brodge, The Rasch model is usually used for item measuremenr and subject of people, in this context examine the relationship between the comparion law and other additional combined measurements is discussed in this fraction test (Brodgen, H. E., 1977).

According to Masters, Rasch modelling can be used for various observation formats, including models for calculation analysis, repeated experiments, and rating scales (Masters, G. N., 1982). In addition, the statistical description of Rasch fitness can give a useful framework for testing the correctness of a person's response, measuring the estimation of a person's response ability, and being able to detect various disturbances to a person's response (Smith R. M., 1986). The Rasch model noted as a probability model from individual response towards an item and because of therefore not explisitly become a response model for itself (Brodgen, H. E., 1977).

In the 1960s, Georg rasch has developed an analytical model of Item Response Theory (IRT) and later was being popular by Ben Wright . The raw data is collected as dichotomy data (true or false) that indicated students ability. The Rasch model make it become a model that relate between students and item (Sumintono, B. and Widhiarso, W., 2014). Beside dichotomy data, Rasch model is used for analysis politomi data that was developed by Andrich, based on two basic theorems, the ability of person and the difficulty level of item. The Rasch model assumed that the difficulty item is disposition that influenced by response of respondence, and ability;s person is a characteristic that influences by the difficulty level estimation (Linacre, J. M., 1999: Nur L et al., 2020). The advatages of Rasch model if compared with classic theory that Rasch model can identify the false answer, identify the assemente that not appropriate, and predict the loss data based on systematic response patterns (Fahmina, S. S. et al., 2019; Goodwin et al.. 2003; Yamtinah et al., 2017)

The topic of this research refers to previous research, where Rasch modeling is used for measuring critical thinking of student's skills in STEM learning in elementary schools (Hamdu G, et. al., 2020). In addition, it was used to develop an instrument for mathematics anxiety, character, and confidence of elementary school students (Karlimah, et al. 2020; Nur, L., 2020; Rusmana, N. et al., 2020). In this study, Rasch modelling is used to evaluate learning on fractional numbers, as well as to describe how Rasch modelling can reveal the level of difficulty and fitness of test questions on fractions. Evaluation is a very important part in the learning process (Jackson, et al., 2002). Generally, the aim of learning evaluation for determining the effectiveness and efficiency and learning of learning system widely.The results obtained from evaluation activities are a description of the quality of something, both concerning value or meaning. Whereas, the activity that finished till assigning value and mening is an evaluation. Describing quality of evaluation is a logical consequence from the process carried out. The process is done systematically and continuously, in the meaning

planned, and also demand of procedure and rules, and continuously (Biggs, J B. & Collis, K. F, 2014).

Method

Measuring the mathematical ability of elementary school students, especially regarding the concepts of and procedur for fractions, a number of test items were given related to the topic. Furthermore, the measurement of the quality of the test questions, that is regarding the level of difficulty and apprppriateness, was carried out. The data collection technique is shown in Figure 1 below which was modified from Hamdu et al (Hamdu, G. et al. 2020).

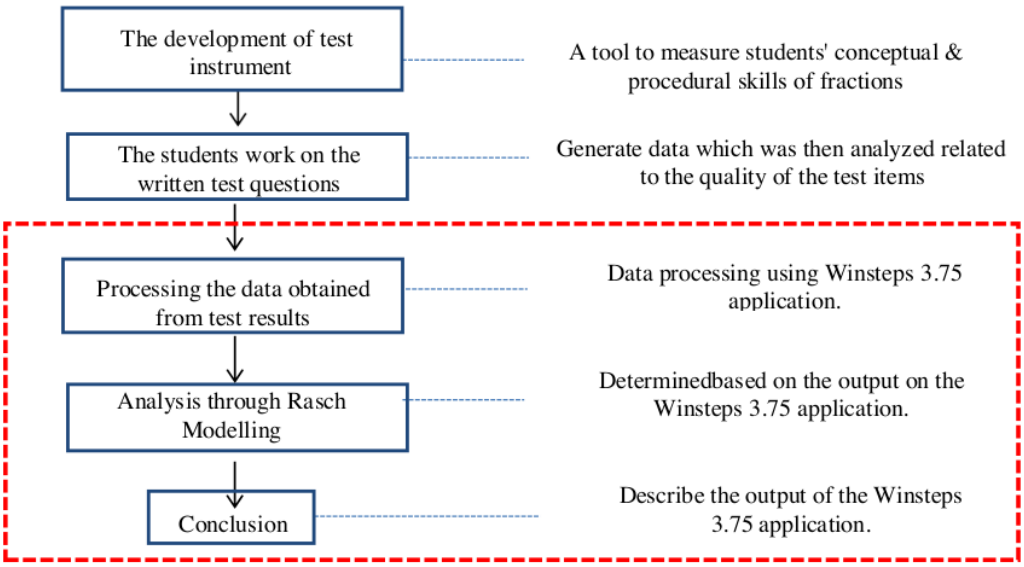

Figure 1.

Data Analysis Stages

The stages of data analysis as shown in Figure 1. began with the preparation of research instruments in the form of written test questions as a tool to obtain research data. Then, by asking stduents to answer the questions, the data related to students' mathematical abilities in topic about fractions was obtained. This study focuses on the stages of data analysis as marked with a red box in Figure 1. Determination of item difficulty level was done by using Rasch modelling assisted by Winsteps 3.75 application which can provide an overview to describe and analyze item difficulty level.

Result

The following are the results of the analysis of test questions through Rasch modelling assisted by the Winsteps 3.75 application.

3.1 Analysis of Item Measure Difficulty Levels.

Table 1. shows several columns that can provide information about difficulty levelfrom each item of fractional number questions. In determining the level of item difficulty, Rasch modelling uses the following categorization standards (1) for the category of very hard question the logit value is greater than +1SD; (2) hard question the value of 0.0 logit +1 SD; (3) easy question the value is 0.0 logit -1 SD; and (4) very easy question the value is less than –SD.

Table 1. Item Statistics: Measure Order

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
29	13	50	2.48	.43	1.11	.5	.95	.1	.60	.63	79.2	84.1	S29
30	15	50	2.13	.40	.97	-.1	1.81	1.6	.60	.63	85.4	82.5	S30
5	17	50	1.82	.39	1.05	.3	1.20	.6	.59	.62	81.3	80.9	S5
27	18	50	1.67	.38	1.01	.1	1.06	.3	.61	.62	79.2	80.0	S27
9	21	50	1.25	.36	.91	-.4	1.12	.5	.62	.60	85.4	77.8	S9
4	22	50	1.12	.36	1.11	.6	1.03	.2	.56	.60	75.0	77.1	S4
22	22	50	1.12	.36	1.23	1.3	1.40	1.3	.49	.60	75.0	77.1	S22
16	23	50	.99	.36	.76	-1.5	.63	-1.3	.69	.59	85.4	76.3	S16
13	26	50	.62	.35	.82	-1.2	.80	-.6	.64	.57	81.3	74.1	S13
23	26	50	.62	.35	.96	-.2	1.50	1.5	.55	.57	81.3	74.1	S23
18	27	50	.50	.35	.88	-.7	.72	-.8	.62	.56	75.0	73.7	S18
19	27	50	.50	.35	1.17	1.2	1.24	.8	.48	.56	70.8	73.7	S19
20	27	50	.50	.35	1.16	1.1	1.45	1.3	.47	.56	70.8	73.7	S20
25	27	50	.50	.35	1.18	1.2	1.36	1.1	.47	.56	70.8	73.7	S25
15	28	50	.38	.35	1.37	2.3	1.58	1.6	.38	.55	62.5	73.5	S15
21	30	50	.14	.35	.97	-.2	.92	-.1	.54	.53	75.0	73.5	S21
7	32	50	-.11	.35	.94	-.3	1.28	.8	.52	.51	83.3	73.7	S7
17	33	50	-.23	.35	.80	-1.4	.63	-.8	.59	.50	75.0	74.4	S17
24	33	50	-.23	.35	.86	-.9	.68	-.7	.57	.50	79.2	74.4	S24
26	34	50	-.36	.36	1.24	1.5	1.23	.6	.38	.49	70.8	75.1	S26
28	35	50	-.49	.36	1.00	.0	1.27	.7	.46	.48	77.1	75.8	S28
11	37	50	-.76	.37	.82	-1.0	.67	-.5	.53	.45	83.3	77.8	S11
6	38	50	-.90	.38	.78	-1.3	.52	-.7	.55	.44	81.3	79.0	S6
2	41	50	-1.37	.42	.86	-.6	.85	.1	.44	.39	89.6	83.4	S2
10	41	50	-1.37	.42	.86	-.6	.78	.0	.45	.39	89.6	83.4	S10
12	41	50	-1.37	.42	.78	-1.0	.53	-.5	.50	.39	85.4	83.4	S12
3	42	50	-1.55	.43	.97	.0	.67	-.1	.40	.37	85.4	84.8	S3
14	42	50	-1.55	.43	1.13	.6	1.08	.4	.31	.37	85.4	84.8	S14
8	44	50	-1.96	.48	.90	-.2	.53	-.3	.39	.33	89.6	88.0	S8
1	49	50	-4.08	1.04	.95	.3	.22	-.4	.21	.15	97.9	97.9	S1
MEAN	30.4	50.0	.00	.40	.99	.0	.99	.2			80.2	78.7	
S.D.	9.2	.0	1.37	.12	.16	.9	.37	.8			7.3	5.6	

Table 1. provides information about the level of difficulty of each item of fractional number question so that the distribution of each item that has been analyzed can be identified.

Table 2. Samples of Test Questions Based on Difficulty Levels

No	Difficulty Level	Test Question Form	Indicator
1	Very Hard	***(Question no. 30)*** Bagas cut the watermelon into 8 parts. Bagas then ate two parts of the watermelon. 2 friends Bagas did likewise. So, the value of the watermelon that Bagas and his friends ate when written in fraction form is... a. $\frac{1}{2}$ c. $\frac{3}{4}$	Shows equivalent fractions with pictures and concrete models.

		b. $\frac{2}{3}$ d. $\frac{3}{2}$	
2	Hard	***(Question no. 22)*** There are 60 students in the fourth grade of Mekar elementary school. On this day there will be 4 students. Each of them will bring 1/60 of 50kg of rice to make *nasi liwet* (*liwet* rice) and eat it together. Therefore, the fourth grade students of SD Mekar, will cook *liwet* rice as much as ….. part of 50 kg of rice. a. $\frac{1}{15}$ c. $\frac{1}{30}$ b. $\frac{2}{15}$ d. $\frac{3}{30}$	Determine the sum, difference, product, and quotient of fractions.
3	Easy	***(Question no. 6)*** A fraction equivalent to $\frac{3}{5}$… a. $\frac{3}{10}$ c. $\frac{3}{100}$ b. $\frac{6}{10}$ d. $\frac{6}{100}$	Explain equivalent fractions.
4	Very Easy	***(Question no. 1)*** The fraction $\frac{1}{8}$ is pronounced as ..... a. One eight c. Eight one b. One eighths d. Eight by one	Pronounce the value of fraction.

The indicators for the form of test questions for each level of difficulty are based on table 3 above, namely; 1) Shows equivalent fractions with pictures and concrete models (very high); 2) Determine the sum, difference, product, and quotient of fractional numbers (high); 3) Explain equivalent fractions (medium); and 4) Pronounce the value of fraction. (low).

2.1 Analysis of Item Fit Order

The level of fitness of fractional numbers test questions (Item Fit) can be determined by using three criteria, namely the outfit mean-square value (Outfit MNSQ), Outfit Z-Standardized (Outfit ZSTD), and Point Measure Correlation (PT-Measure Corr) (Bond, T. G. & Fox. The criteria used to check for non-conforming items (outlier or misfit) are:

1. The value of the Outfit square-mean (Outfit MNSQ) received: 0.5 < MNSQ < 1.5.
2. The value of Outfit Z-Standardized (Outfit ZSTD) received: -2.0 < ZSTD < +2.0.
3. Point Measure Correlation Value (PT-Measure Corr): 0.4 < PT-Measure Corr < 0.85

Table 3. Item Statistics: Misfit Order

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
30	15	50	2.13	.40	.97	-.1	1.81	1.6	A .60	.63	85.4	82.5	S30
15	28	50	.38	.35	1.37	2.3	1.58	1.6	B .38	.55	62.5	73.5	S15
23	26	50	.62	.35	.96	-.2	1.50	1.5	C .55	.57	81.3	74.1	S23
20	27	50	.50	.35	1.16	1.1	1.45	1.3	D .47	.56	70.8	73.7	S20
22	22	50	1.12	.36	1.23	1.3	1.40	1.3	E .49	.60	75.0	77.1	S22
25	27	50	.50	.35	1.18	1.2	1.36	1.1	F .47	.56	70.8	73.7	S25
7	32	50	-.11	.35	.94	-.3	1.28	.8	G .52	.51	83.3	73.7	S7
28	35	50	-.49	.36	1.00	.0	1.27	.7	H .46	.48	77.1	75.8	S28
26	34	50	-.36	.36	1.24	1.5	1.23	.6	I .38	.49	70.8	75.1	S26
19	27	50	.50	.35	1.17	1.2	1.24	.8	J .48	.56	70.8	73.7	S19
5	17	50	1.82	.39	1.05	.3	1.20	.6	K .59	.62	81.3	80.9	S5
14	42	50	-1.55	.43	1.13	.6	1.08	.4	L .31	.37	85.4	84.8	S14
9	21	50	1.25	.36	.91	-.4	1.12	.5	M .62	.60	85.4	77.8	S9
29	13	50	2.48	.43	1.11	.5	.95	.1	N .60	.63	79.2	84.1	S29
4	22	50	1.12	.36	1.11	.6	1.03	.2	O .56	.60	75.0	77.1	S4
27	18	50	1.67	.38	1.01	.1	1.06	.3	o .61	.62	79.2	80.0	S27
21	30	50	.14	.35	.97	-.2	.92	-.1	n .54	.53	75.0	73.5	S21
3	42	50	-1.55	.43	.97	.0	.67	-.1	m .40	.37	85.4	84.8	S3
1	49	50	-4.08	1.04	.95	.3	.22	-.4	l .21	.15	97.9	97.9	S1
8	44	50	-1.96	.48	.90	-.2	.53	-.3	k .39	.33	89.6	88.0	S8
18	27	50	.50	.35	.88	-.7	.72	-.8	j .62	.56	75.0	73.7	S18
24	33	50	-.23	.35	.86	-.9	.68	-.7	i .57	.50	79.2	74.4	S24
2	41	50	-1.37	.42	.86	-.6	.85	.1	h .44	.39	89.6	83.4	S2
10	41	50	-1.37	.42	.86	-.6	.78	.0	g .45	.39	89.6	83.4	S10
11	37	50	-.76	.37	.82	-1.0	.67	-.5	f .53	.45	83.3	77.8	S11
13	26	50	.62	.35	.82	-1.2	.80	-.6	e .64	.57	81.3	74.1	S13
17	33	50	-.23	.35	.80	-1.4	.63	-.8	d .59	.50	75.0	74.4	S17
12	41	50	-1.37	.42	.78	-1.0	.53	-.5	c .50	.39	85.4	83.4	S12
6	38	50	-.90	.38	.78	-1.3	.52	-.7	b .55	.44	81.3	79.0	S6
16	23	50	.99	.36	.76	-1.5	.63	-1.3	a .69	.59	85.4	76.3	S16
MEAN	30.4	50.0	.00	.40	.99	.0	.99	.2			80.2	78.7	
S.D.	9.2	.0	1.37	.12	.16	.9	.37	.8			7.3	5.6	

Based on the discussion and Table 3. above, it is evident that items 30, 15, and 1 did not meet the MNSQ value; all items met the ZSTD value; and items 15, 26, 14, 1, and 4 did not meet the PT-Measure Corr value.

Discussion

A calibrated assessment instrument can verify student response patterns appropriately. In this case, Rasch modelling in principle specifically calibrates the measurement scale, respondents (person) and items (items). The way Rasch modelling works is by processing score data based on per person (person) and score data per item (item). The two scores become the basis for estimating the true score in logit scale which can indicate the level of difficulty of the items. Raw scores processed through Rasch modelling produce true/logit scores that have been measured using the same or equivalent intervals.

Assessment instruments that are processed through Rasch modelling are educational assessments. This study discusses more specifically the assessment instrument in mathematics learning in elementary schools, as an effort to determine mathematics learning that can provide an alternative implementation of mathematics learning so that students acquire mathematical knowledge, numeracy skills, and foster critical attitudes which still need to be realized. To acquire mathematical knowledge, skills and attitudes, one must systematically master mathematical concepts and procedures. One of the mathematical topics that is considered and often is problematic is Fractional numbers. In Indonesia, fractional numbers

are mathematical topic that is studied by fourth grade elementary school students. Therefore, the author first needs to know competences and incompetencs of the fourth grade elementary school students regarding fractions. For this reason, the authors focus on the discussion of the test instrument. Can the test instrument for fractions measure the students' conceptual and procedural abilities in fractions?

The following are the Basic Competences (BC) of mathematics on the topic of fractions.

Table 1. Basic Mathematics Competences on Fractional Numbers in Elementary School

No	Basic Competences
1	BC 3.1. Explain equivalent fractions with pictures and concrete models.
2	BC 3.2. Describes the various forms of fractions (common, mixed, decimal, and percent) and the relationships between them.
3	BC 3.3. Explain and perform an estimation of the sum, difference, product, and quotient of two whole numbers as well as fractions and decimals.
4	BC 4.1. Identify equivalent fractions with pictures and concrete models.
5	BC 4.2. Look for different forms of fractions (common, mixed, decimal, and percent) and the relationships between them.
6	BC 4.3. Solve problems about estimating the sum, difference, product, and quotient of two whole numbers as well as fractions and decimals.

Then, an analysis of test questions based on BC in Table 1. was carried out. The test questions were given to elementary school students in the city of Tasikmalaya.

The categorization of thedifficulty level of the items was done through a combination of the standard deviation (SD) value and the logit mean value (Sumintono, B. & Widhiarso, W., 2015).Based on the explanation and analysis of item measure difficulty level on result above, the results of the analysis of all fractional number questions can be grouped as follows:

1. Group of very hard question items consists of questions no. 29, no. 30, no. 5 and no. 27.
2. Group of hard question items consists of questions no. 9, no. 4, no. 22, no. 16, no. 13, no. 23, no.18, no.19, no.20, no. 25, no. 15, and no. 21.
3. Group of easy question items consists of questions no. 7, no. 17, no. 24, no. 26, no. 28, no. 11, and no. 6.
4. Group of very easy question items consists of questions no. 2, no. 10, no. 12, no. 3, no. 14, no. 8, and no. 1.

If the questionson three criteria (MNSQ, ZSTD, and PT-Measure Corr), it can be ascertained that the questions are not good enough so they need to be repaired or replaced (Biggs, J. B. & Collis, K. F, 2014; Jackson, et. al., 2002). From this quote, all of the fractional number items analyzed had an acceptable level of fitness and deserved to be kept because

there were no items that did not meet the three criteria. This meant that the difficulty level of the fractional number test questions was appropriate in each category, that is very hard, hard, easy and very easy. In the very hard category questions, the percentage of students with correct answers tended to be the lowest compared to other question categories. However, in the categories hard, easy, and very easy questions, the percentage of students with correct answers tended to vary with several possibilities that might occured occured such as students answered the questions by guessing, by cheating on each other, or by paying less attention on accuracy. These possibilities might occured in some questions which are categorized as hard, easy, and very easy because of the pattern of presentation of the questions or the different levels of students' abilities. This reasoning can certainly show that there were various levels of difficulty of test items that were good for identifying various student abilities.

Conslusion

Rasch modelling assisted by the Winsteps 3.75 application makes it easy for users to analyze the assessment instrument (test questions) where the raw scores are processed and the specifically provides analysis on the design of the items used and whether the score pattern used is appropriate. Based on the results, it can be concluded that several test questions showed a various level of difficulty with an acceptable level of fitness. The difficulty level related to the fractional numbers questions, namely, 1) the majority of hard items were found in the indicator of the ability to show equivalent fractions with pictures and concrete models; 2) the majority of very hard items were found in the indicator of the ability to determine fractions based on pictures, determine the product and quotient of the fractional numbers and explain the form of mixed fractions; 3) the majority of easy questions were found in the indicator of the ability to determine the sum and difference of fractional numbers; 4) the majority of very easy questions were found in the indicator of the ability to pronounce equivalent fractions.

The results of the analysis through Rasch modelling were more specifically to provide a comprehensive picture of mathematics learning that was carried out on a certain subject and time. The results of the Rasch modelling analysis may be different or same depending to learning conditions and situations, such as relating to the characteristics of students, and implementers of mathematics learning in certain classes or schools. However, the analysis process of Rasch modelling can be used by teachers in schools to be able to comprehensively identify the learning process and make test questions.

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