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Instrument Validation of Students' Analytical Thinking Skills in The Natural Science Learning by Using the Rasch Model

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ABSTRACT
The aim of this study is to validate the analytical thinking skills test instrument using the Rasch Model. The method uses quantitative research methods The essay test was used to evaluate the 85 students attending the PGMI IAIN Surakarta Study Program in Indonesia. Data analysis used the Rasch model–quest application because this model is known for its use in the item response theory. The essay test used to measure student analytical thinking skills in the natural science class was found to be valid, with an adequate level of difficulty, and most of the questions were within the range of student abilities. This study found a prototype instrument for analytical thinking skills in natural science learning through the analysis of the Rasch Model. This instrument can be used to help students measure their ability to think critically and analytically. The results can be used as a reference for instructors and researchers in designing, producing, and analyzing instruments for teaching students' analytical thinking skills in natural science learning.

INTRODUCTION

One of the biggest challenges for education in Indonesia is student thinking skills development. The fundamental thinking skills are critical thinking skills comprising analytical skills, synthesis, and evaluation [1]. Analytical thinking skills are essential to developing higher-order thinking skills. [2], which represent the demands of 21st-century skill development [3].

Students need to be able to think critically in order to improve their learning, which is an essential ability used in solving problems in various fields [4], in encountering the challenges of everyday life [5]. Several studies indicate The ability to think analytically can help improve the learning process [6] [7], and to optimize their ability to solve problems [8].

The analytical thinking skills of Indonesian students were still in the low category based on the results of the PISA survey in 2015. Also, Indonesia occupied 60th or 14th lowest of 74 countries in mathematical and scientific ability [9], including analytical thinking skills. The inadequate analytical thinking skills of students are caused by a lack of stimulation in learning that involves thinking

analysis [10]. Therefore, learning must be able to produce students who think analytically [11], the teaching and learning process must be focused on developing the student's analytical thinking skills to a higher level [12].

Analytical thinking skills involve a series of mental processes in identifying solutions to many problems, include analyzing, assessing, evaluating, and comparing [13]. Indicators of analytical thinking skills are distinguished, organizing, and attributing [14]. Concurrently, according to Marzano and Kendall, there are five indicators of analytical thinking skills: matching, classifying, error analysis, generalizing, and detailing [15]. Another expert opinion states that indicators of critical thinking skills consist of elemental analysis, relationship analysis, principle analysis, and organizing [16]. Researchers synthesize from several opinions of experts that indicators of analytical thinking skills are matching, classifying, principle analysis, organizing, and relationship analysis.

Based on indicators of analytical thinking skills, a test instrument was developed by collecting samples on science learning, new and renewable energy materials. The critical thinking skills test instrument was analyzed using the Rasch Model. The Rasch model meets objective measurement requirements: analysis is carried out on each item, can reveal a consistent pattern of respondent answers, can reveal which respondents tend to answer carelessly, and detects bias on the items being tested [17]. The Rasch Model can be adopted to document and evaluate the measurement function of the instrument [18].

Based on the explanation in this introduction, The purpose of this study is to validate the analytical thinking skills test instrument using the Rasch Model. This study summarizes the results of the instrument development regarding the suitability of the items with the Rasch Model, the validity of the items, and the level of difficulty of the items.

METHOD

The method employed in this research was quantitative research methods. Data collection was through an essay test given to 85 students of the PGMI IAIN Surakarta Study Program, Indonesia. The instrument was developed by taking natural science material in the Science Basic Concepts course. Aspects, indicators, and instrument grids are presented in Table 1, Table 2, and Table 3.

Table 1. Aspects of analytical thinking skills

Aspects of Analytical Thinking Skills			
Anderson [14]	Marzano [15]	Montaku [16]	Researcher's Synthesis
Differentiate	Match	Elements analysis	Match
Organize	Classify	Attributing analysis	Classify
Attribute	Error analysis	Principles analysis	Principles analysis
	Generalize	Organize	Organize
	Detail		Attributing analysis

Table 2. Indicators of analytical thinking skills instrument

No	**Aspect of Analytical Thinking Skills**	**Indicator**
1	Match	Identify (The process of introducing concepts is based on conformity with the facts observed)
2	Classify	Detail (The process of classifying/classifying observed facts to obtain concepts)
3	Principles analysis	Communicate the result (Processing data through the process of data analysis, then discussing the results of the analysis obtained and presenting them in the form of diagrams, graphs or tables), implement the concept (Applying concepts in everyday life)

No	Aspect of Analytical Thinking Skills	Indicator
4	Organize	Plan the experiment (Prepare equipment, materials, and conduct experiments)
5	Attributing analysis	Calculate (make calculations of the relationship between variables), interpret (interpret the results of mathematical calculations into physical language)

Table 3. Grid of items for analytical thinking skills

No	Indicator of questions	No Item	Total Item	Item form
1	Students are able to identify data presented in tables or images.	1, 9	2	essay
2	Students are able to detail data presented in tabular form.	2	1	essay
3	Students are able to apply the concept of data presented in tabular form.	3	1	essay
4	As explained by the equipment, students were able to design experiments	4, 5	2	essay
5	Provided the experimental results, students are able to calculate the value of the variable being sought.	6, 10	2	essay
6	Provided data on the results of experiment, the students are able to interpret the results of the analysis of the variables obtained.	7	1	essay
7	Presenting the results of the experiment, students were able to communicate the results of the experiment to make a conclusion	8	1	essay
Number of questions			10	

Use this Rasch Model application in analyzing and processing data because it is based on item response theory (IRT). The Rasch Model also offers many easier solutions to better analytical measures of the psychometric scale assessment and providing better information [19]. The criteria for suitability with the Rasch model, the validity of the items, and the difficulty level of the items are presented in Table 4, Table 5, and Table 6.

Table 4. Criteria of the fit items with the Rasch model [20]

The score of Infit MNSQ	Information
> 1.33	Misfit with the Rasch Model
0.77 – 1.33	Fit with the Rasch Model
< 0.77	Very fit withthe Rasch Model

Table 5. Criteria of Valid items [20]

The value of Outfit t	Information
≤ 2.00	Valid items
>2.00	Unvalid items

Table 6. Criteria of item difficulty [20]

The value of Treshold (b)	Information
$b > 2$	Very difficult
$1 < b \leq 2$	Difficult
$-1 < b \leq 1$	Moderate
$-1 > b \geq 2$	Easy
$b < -2$	Very easy

RESULTS AND DISCUSSIONS

Fit with the Rasch Model

To find out whether the developed items meet the criteria of fit with the Rasch Model or are unanalyzed with the Quest application, the item compatibility data with the Rasch Model is shown in Figure 1.

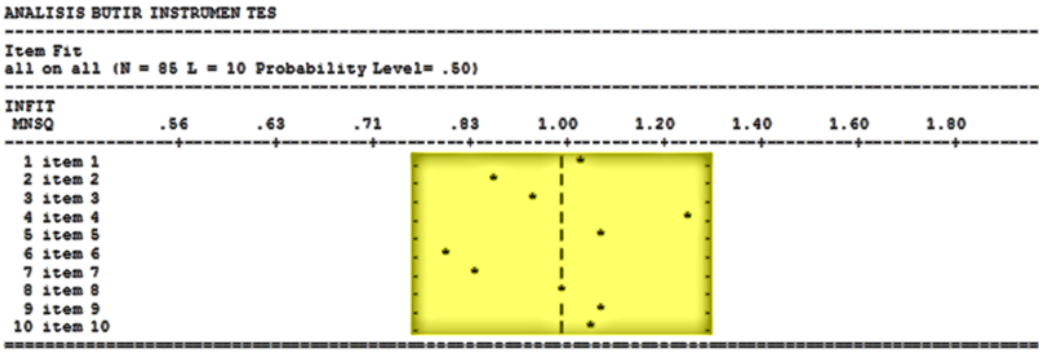


Fig 1. *The infit mean square item*

Referring to the standard Quest Application, if the mean-square infit value is between 0.77 and 1.33, then the item fits the Rasch Model. As shown in figure 1, items number 1 to number 10 are between the values 0.77 and 1.33. So, it can be concluded that all the items fit the Rasch model. The items fit the Rasch Model, meaning that the items developed to meet the criteria set out in the Rasch Model.

Validity of Question Items

Valid items can retrieve research data, while invalid items are excluded. The procuration of Quest Application output can be found in Figure 2.

ANALISIS BUTIR INSTRUMEN TES

Item Estimates (Difficulty and Taus) In input Order
all on all (N = 85 L = 10 Probability Level= .50)

	ITEM NAME	SCORE	MAXSCR	DIFFCLTY	TAU/S 1	2	3	4	INFT MNSQ	OUTFT MNSQ	INFT t	OUTFT t
1	item 1	117	170	-.70	-.84	.84			1.04	1.04	.4	.3
				.18	.40	.22						
2	item 2	119	170	-.86	-1.04	1.04			.88	.88	-.9	-.7
				.19	.47	.22						
3	item 3	117	255	.23	-.17	.04	.13		.94	.97	-.5	-.2
				.11	.25	.23	.28					
4	item 4	114	255	.28	.14	-.26	.12		1.26	1.31	2.3	1.8
				.10	.24	.23	.28					
5	item 5	107	255	.31	-.37	.30	.08		1.08	1.09	.7	.6
				.11	.25	.24	.29					
6	item 6	85	170	.12	-.19	.19			.81	.80	-2.1	-1.4
				.14	.24	.24						
7	item 7	125	255	.36	-1.49	-.49	1.98		.85	.85	-1.0	-.8
				.15	.36	.22	.52					
8	item 8	131	255	.10	.07	-.15	.09		1.00	.99	.0	.0
				.10	.26	.23	.25					
9	item 9	134	255	.10	.23	-.44	.20		1.08	1.09	.7	.6
				.10	.26	.23	.25					
10	item 10	136	255	.06	-.22	-.25	.47		1.05	1.08	.5	.5
				.11	.28	.23	.26					

Fig 2. *Outfit data to determine the validity of the items*

Based on the Quest application, the items are valid, which means they pass to be used in research if Outfit t < or = 2.00. Meanwhile, if the Outfit t > 2.00, the items are invalid, which cannot be used in collecting research data. The Rasch Model can define valid item constructs and provide clear definitions of measurable constructs consistent with theoretical expectations [21]. More detailed information is in Table 7.

Table 7. The result of the validity of each item

Item Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
The score Outfit t	0.3	–0.7	–0.2	1.8	0.6	–1.4	–0.8	0.0	0.6	0.5
Decision	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid

It can be seen in Table 7, that the 10 items are all valid so that all the items can be used for data collection and by lecturers in learning science, especially new and renewable energy materials. Valid instruments demonstrate the potential to describe effective teaching development [22]. Analytical thinking skills instruments (10 items) are all valid because they have been designed with logical reasoning and follow developing theories.

Item difficulty level

To find out the difficulty level of the questions, from the analysis output of the Quest Application, if the threshold value is > 2, then the question is very difficult. If the threshold value is > or = –2, then the question is easy. If the threshold value is < = –2, then it is very easy. The difficulty level of the items is as in Table 8.

Table 8. The level of item difficulty

Item number	**The score of thresholds**	**Decision**
1	0.28	Moderate
2	0.30	Moderate
3	0.91	Moderate
4	0.91	Moderate
5	1.02	Difficult
6	0.68	Moderate
7	2.41	Very difficult
8	0.73	Moderate
9	0.74	Moderate
10	0.9	Moderate

Based on Table 8, very difficult item is number 7, difficult item is number 5, moderate items are number 1, 2, 3, 4, 6, 8, 9, and 10. Item number 7 is presented in Figure 3.

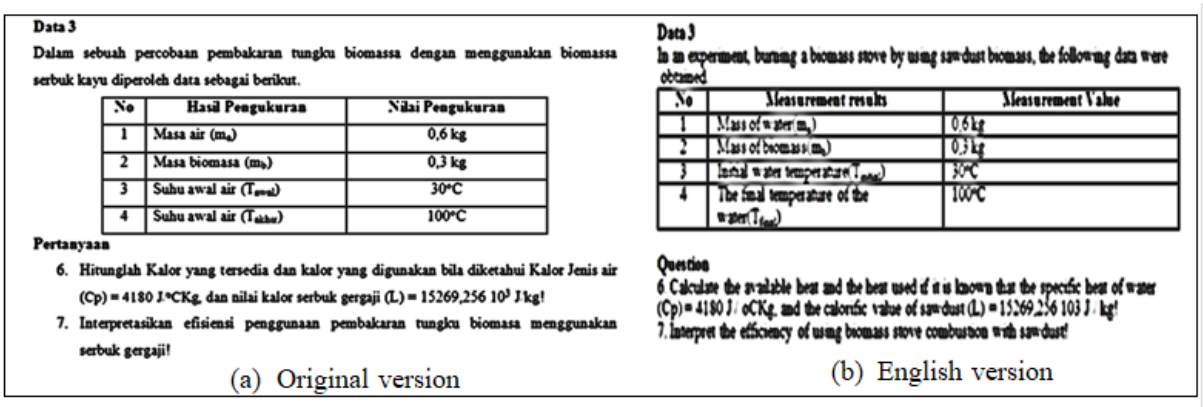


Fig 3. *Item Number 7*

Item number 7 is the most difficult item because to answer item 7, the students must be able to answer item number 6 first. If students can answer question number 7, it means students have been able to do relationship analysis.

Items within the range of students' abilities
From the results of the Quest Application analysis output, there are items that are beyond the range of students' abilities, and some are within the range of students' abilities, as in figure 4.

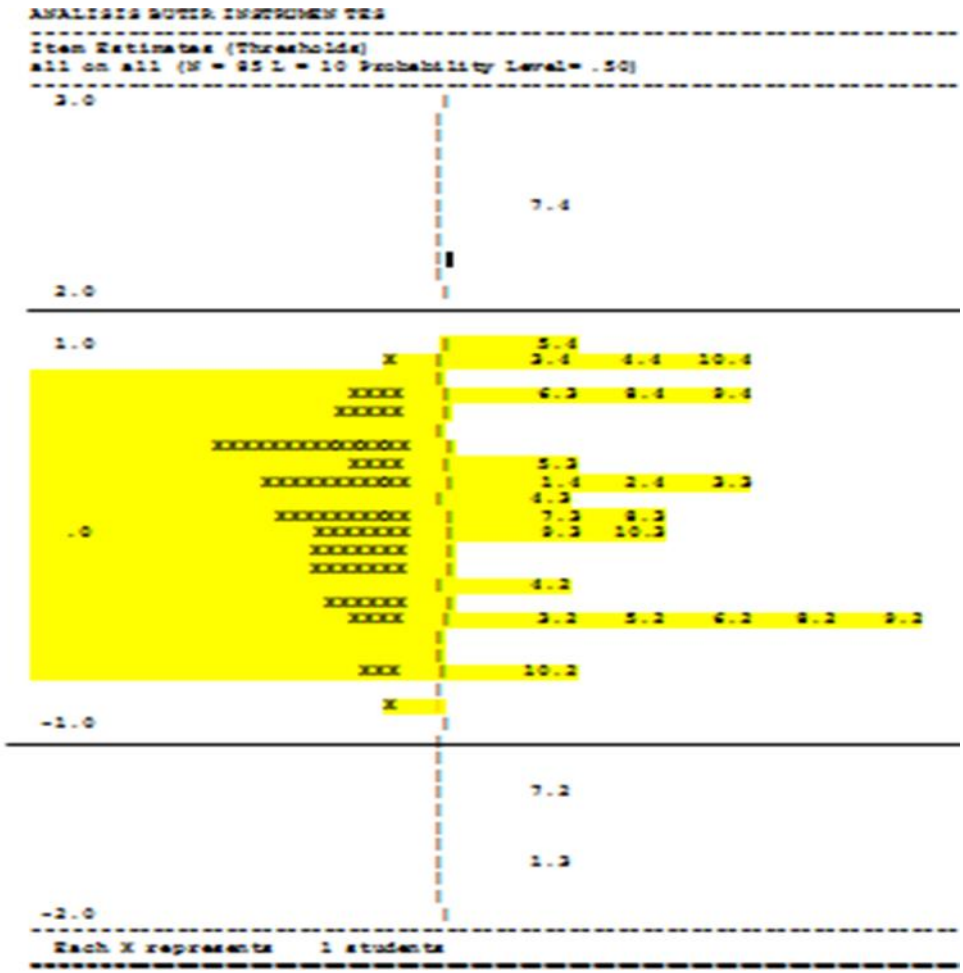
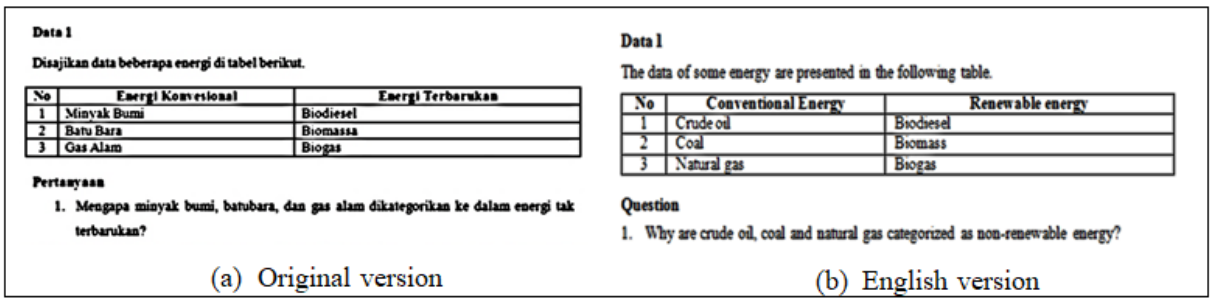


Fig 4. *Items within the range of learners' abilities*

No student can work on item 7 with a value of 4, but students are very easy to solve item number 7 with a value of 2 and item number 1 with a value of 3. Question number 1 is presented in Figure 5.



Data 1

Disajikan data beberapa energi di tabel berikut.

No	Energi Konvesional	Energi Terbarukan
1	Minyak Bumi	Biodiesel
2	Batu Bara	Biomassa
3	Gas Alam	Biogas

Pertanyaan

1. **Mengapa minyak bumi, batubara, dan gas alam dikategorikan ke dalam energi tak terbarukan?**

(a) Original version

Data 1

The data of some energy are presented in the following table.

No	Conventional Energy	Renewable energy
1	Crude oil	Biodiesel
2	Coal	Biomass
3	Natural gas	Biogas

Question

1. Why are crude oil, coal and natural gas categorized as non-renewable energy?

(b) English version

Fig 5. *Item number 1*

Most of the items within the range of students' abilities are item number 1, 2, 3, 4, 5, 6, 8, 9, and 10. This section links the respondent's ability to the item because the analysis of the instrument items is associated with the respondent's ability, which helps to construct a valid instrument [23].

Based on data analysis, the instrument of students' analytical thinking skills in science learning has met the compatibility with the Rasch model. The Rasch model meets objective measurement criteria: analysis is carried out on each item, demonstrates a consistent pattern of respondent answers, reveals which respondents tend to answer carelessly, and detects bias on the items being tested [17]. Besides, the Rasch Model has the advantage of being able to explain items and people [24].

The instrument of students' analytical thinking skills in science learning has also met the validity criteria, after being tested and analyzed. Trial is a step to test the instrument so that its validity is known [25]. Valid means that the instrument used can measure what is being measured. In addition to meeting validity requirements, a research instrument must also meet reliability requirements [26].

In addition to compatibility with the Rasch model and validity, the instrument of students' analytical thinking skills in science learning has met the criteria of an adequate level of difficulty. A good instrument must reach all measured aspects [27]. The Rasch model is an application that can evaluate whether an instrument can measure because the Rasch model can show the items of the instrument which are very difficult, difficult, moderate, and easy by the respondent, and juxtaposing the ability of the respondent [28]. In this instrument, most of the questions were within the range of students' abilities. Students have demonstrated high-level thinking skills, connecting and providing explanations between facts and concepts, categorizing and manipulating facts, and using them in various situations [29]. This is important for students to achieve success [30].

Researchers believe that the analytical thinking skills instrument of students in science learning analyzed with the Rasch model can inspire lecturers and further researchers in developing the instrument. Analytical thinking skills need to be promoted continuously, including the making of the instrument, to empower higher-order thinking skills among students.

CONCLUSION AND SUGGESTION

Based on data analysis, the rasch model analytic tools that test essays on value or score 10 points are valid with the distribution of item preferences of 1 item very difficult, 1 item difficult, and 8 items moderate, and can be used and tested their usage, so they can be used and redeveloped by professors or other researchers interested in designing, analyzing and developing instruments for the mind-based student skills of rasch, especially in learning or the field of science.

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