Application of Rasch Model for Validating Creative Thinking Test on Solar Cell Material

Arifin Septiyanto[1], Eka Cahya Prima[1], Lilit Rusyati[1], Lia Lutianasari[3], Andhy Setiawan[2]

[1] Department of Science Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No.229, Isola, Kec. Sukasari, Kota Bandung, Jawa Barat 40154, Indonesia

[2] Department of Physic Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No.229, Isola, Kec. Sukasari, Kota Bandung, Jawa Barat 40154, Indonesia

[3] SMP N 19 Bandung, Jl. Sadang Luhur XI, Sekeloa, Kecamatan Coblong, Kota Bandung, Jawa Barat 40134, Indonesia

Corresponding Author. E-mail:
[1] arifinseptiyanto3@upi.edu
[1] ekacahyaprima@gmail.com
[1] lilitrusyati@upi.edu
[2] andhys@upi.edu
[3] lialutianasari72@guru.smp.belajar.id

Abstract

Creativity is essential for work, thinking, and life in the twenty-first century. Teaching solar cells can influence and encourage students' creative thinking skills. This research aims to evaluate the creative thinking skills of Indonesian students, validate the innovative thinking skills test adapted for Indonesia, and classify the difficulty level of the questions and students' creative thinking skills. The participants were 32 students from 10th-grade high school at a college in Bandung, West Java, Indonesia. The creative thinking skills test consists of essay questions. Data collection was carried out through paper-based tests. The results of the Rasch analysis show that the adapted creative thinking skills test meets the validity and reliability criteria based on Rasch parameters. Differential item function (DIF) analysis shows that only two of the 12 items fall into the bias question category, so they need to be reviewed. The study's implication can help teachers and researchers anticipate student success rates in disciplines other than mathematics and science. This is because creative thinking skills must be included in the Merdeka curriculum.

Keywords: Creative thinking test, Solar cell, Rasch analysis.

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INTRODUCTION (10%)

Creativity is important for both individuals and society, and it is viewed as a crucial aspect of engagement and contribution to life and society (Cheng 2019; Li 2023; Mazla et al. 2019). Creativity is commonly considered necessary for work, thinking, and living in the 21st century (Lyskova 2018; Nakano and Wechsler 2018). The continual changes that modern society is experiencing place new demands on education to fulfill the goal of instilling and cultivating creativity in students' personalities. Promoting students' creativity is an essential educational goal (Bui, Kazarenkov, and de Tran 2020; Sadeghi and Ofoghi 2011; Thuy and Ilyich 2020). Creativity and innovation in education are regarded as both an opportunity and a necessity. These are seen as a fundamental component of the objectives of existing and future educational systems (Jumini et al. 2023; OECD 2016).

Over the last two decades, academics have investigated problems associated with teaching and promoting creativity in pupils through education. Modern psychologists and educators believe that creativity may be taught (Hernández-Torrano and Ibrayeva 2020; Kupers et al. 2019; Plucker, Beghetto, and Dow 2004). Creativity extends beyond art into the economy and everyday life, including cleaning and other tasks requiring extensive knowledge and expertise. Creativity enables focused work, effective socialization, proficient use of technology, and daily issue solving (Lidinillah et al. 2020; Runco and Jaeger 2012). Teachers are becoming increasingly concerned about changes in the current educational process and their own role in it. In this scenario, the teaching technique has evolved greatly in recent years, taking the form of speeches, seminars, projects, workshops, and so on (Grassini 2023). Teachers at modern universities must serve as moderators, facilitators, consultants, and tutors (Regan 2012)Teachers should be there to help, motivate, and encourage students as needed. They create settings where students can exhibit their freedom, activity, and creativity. They must continually change and adapt to meet the demands and conditions of modern education. We can argue that the teacher has a role in education in general and student creativity development in particular.

Teaching creativity is a creative process in which students can think to solve problems creatively (Akhmad, Masrukhi, and Indiatmoko 2020; Calavia, Blanco, and Casas 2021; Fatmawati, Jannah, and Sasmita 2022; Kijima, Yang-Yoshihara, and Maekawa 2021). Improving creative thinking skills in education is crucial for developing self-actualization, problem-solving abilities, and a sense of usefulness and satisfaction (Hafina and Fitri 2023)Creative thinking skills occur in the learning process when students explore ideas that can be applied to solving problems. Studies have also been conducted worldwide on the formation and growth of students' creativity and instruments to measure the various components of teaching creativity. However, there has been little study on psychometric property analyses of creative thinking tests on solar cell material in senior high school.

Test development on solar cell material for senior high school level based on electricity and renewable energy topic. Teaching about solar cells in schools is critical because it raises environmental consciousness by teaching kids how to harvest energy from the sun, a clean and sustainable resource (Restrepo et al. 2022). This knowledge instills an understanding of the environmental benefits of solar energy and fosters a sense of responsibility for sustainable actions. Second, including solar cell information in the curriculum is consistent with the overall goals of STEM education (Chien et al. 2021). It enables the application of scientific principles, technological concepts, and engineering abilities, as well as building a comprehensive understanding of these disciplines. Furthermore, understanding solar cell technology is critical for technical literacy, as it prepares pupils for a society in which renewable energy is key (Dark 2011). Beyond academics, educating about solar cells can pique students' interest in renewable energy careers, helping to produce a trained workforce for the developing green energy sector. Overall, solar cell education teaches students the knowledge and skills they need to make informed energy decisions, encourages creativity, and fosters a sense of global citizenship by addressing environmental challenges. As a result, building tools for creative thinking skills on solar cell material is required to help teachers learn about solar cells. This study employed the model to assess the research problem's validity and efficacy.

The Rasch model is a modern approach to developing a measuring instrument with enough validation and reliability (Bond & Fox, 2015). The Rasch model provides a framework for evaluating the scale's properties, including the point-measure correlation coefficient (PTMEA Corr), item infit and outfit values, item level of difficulty, reliability, and questionnaire separation and stratum statistics. As a result, it can guarantee the consistency of the investigated factor structure (Sumintono & Widhiarso, 2015). Furthermore, the Rasch analysis evaluates the soundness of a scale using multiple sources of information. Furthermore, it reviews theoretical constructions and specifies which aspects should be changed or replaced to ensure the scale's overall quality. This method has grown in popularity in recent years for evaluating the psychometric properties of scales across various disciplines. This study aims to create and validate a creative thinking exam for solar cell material using the Rasch model analysis.

METHOD (15%)

Participant

The study used a cross-sectional research design and a quantitative method. It used convenience sampling to select 32 students, 13 male and 19 female, from senior high schools in Bandung, West Java, Indonesia. Students signed a written consent form before taking the creative thinking skills test. To preserve their personal information, students were guaranteed anonymity. Participants were given 65 minutes to complete the creative thinking test with teacher instruction during the test.

Instrument

The creative thinking skills instrument used in this study refers to the indicators of creative thinking skills developed by Torrance, (1977). Before the creative thinking test is used, the researcher asks for expert judgment to validate the test. The type of instrument used to measure creative thinking skills is an essay test. A total of 12 essay questions were used to measure creative thinking skills, where each indicator consisted of 2 questions. Then, the same creative thinking test questions were used in the pre-test and post-test. The lattice of creative thinking test questions can be seen in Table 1. The creative thinking essay test is built based on the topic of solar cells, which refers to the Merdeka Curriculum.

Table 1. Creative thinking test question grid

Indicator	Competency indicator	Question number	Total
Fluency (FL)	Explain the effect of solar energy in reducing the effects of global warming	1	3
	Explain the impact of solar energy use on energy consumption	2	
	Explain the advantages and disadvantages of installing solar cells in Indonesia	12	
Flexibility (FE)	Analyze the performance factors of solar cells	3	3
	Connecting the effect of light intensity to the power produced by solar panels	4	
	Explaining the impact of using solar panels	5	
Elaboration (E)	Explain the advantages of DSSC over previous-generation solar cells	11	3
	Deciphering the cost savings of solar panels	6	
	Break down the number of solar panels required	7	
Originality (O)	Designing a simple solar panel research	8	3
	Design solar panel applications to solve problems.	9	
	Explain alternative solutions to the carbon emission problem	10	

Data Analysis

Data analysis was carried out using the Rasch measurement program WINSTEPS version 5.1.4. Rasch's analysis utilized joint maximum likelihood estimation (JMLE) to turn student scores into a logit scale (interval data) ranging from negative to positive infinity. Rasch parameter evaluation was used to evaluate validity and reliability, considering unidimensionality, local independence, and person and item reliability requirements. The Wright map confirmed the targeting requirements for the item and the person. Then, the difficulty level can be categorized in Table 2 according to the data categorization (Planinic et al., 2019). DIF analysis was utilized to assess item bias following gender.

Table 2. Item difficulty categorization

Logit	Value	Category
>+1SD	> 1.24	Very difficult
0.00 logit +1SD	0.00-1.24	Difficult
0.00 logit -1SD	0.00–(1.24)	Easy
<-1SD	< (-1.24)	Very easy

RESULT AND DISCUSSION

Validity of Creative Thinking Test

Creative thinking test on the estimation of solar cell materials in the form of ratio data using Rasch analysis to determine the validity of the test. Instrument validity is the degree to which the items in the instrument represent components in the entire area of the object to be measured and the extent to which they reflect the behavioral characteristics to be measured (Retnawati 2016). The item and person criteria were utilised to verify the creative thinking test. Person and item fit validity was determined using the mean of infit and outfit mean squares (MNSQ), which has an acceptable range of 0.5 to 1.5. However, 1.6 is still considered acceptable. Furthermore, the ideal values of the fit criterion are near 1.00 logit (Andrich 2018; Bond and Fox 2015). The infit and outfit z-standardized (ZSTD) of persons and items were used in this analysis (Azizan et al. 2020). Furthermore, item separation demonstrated that the creative thinking test has a variety of easy and difficult items (Boone 2016). Separation values must be greater than two logits, and the higher the separation index, the higher the test's quality (Bond and Fox 2015; Boone 2016; Planinic et al. 2019). The Rasch analysis results are shown in Table 2. The results confirmed that the modified design for the test for Indonesia fulfilled the Rasch parameter for each task and the complete test.

WINSTEPS software can estimate both unidimensional and multidimensional Rasch models by examining subtests. In this study, we evaluated the task as a subtest as a unidimensional model based on Fox's (2015) recommendation, in which the creative thinking test was constructed to assess an underlying construct of unique but related sub-dimensions. Aryadoust & Raquel (2019) I suggested utilizing WINSTEPS to evaluate the unidimensionality of a subtest while using a multidimensionality model as a basic assumption. The creative thinking test's construct validity was confirmed by assessing unidimensionality and local independence. Table 1 shows the raw variance values by metric for all tasks. The results revealed that the creative thinking test met an acceptable threshold of more than 30%. The first contrasting values had an unexplained variance of less than 2 for all activities, confirming unidimensionality. This suggests the test had close to four dimensions depending on the tasks. Local independence indicates that the items in the creative thinking skills test were independent. The raw residual correlation between pairs was also calculated to determine local independence. The raw residual correlation between pairs of items must be less than 0.3 (Table 3).

The result indicated that the creative thinking test is valid and acceptable for the research. These results are from research conducted by (Rosidin, Herliani, and Viyanti 2023), which shows that the MNSQ value of both outfits and itfit is between 0.5 and 1.5. This research contributes to assessing creative thinking skills using the Rasch measurement approach. The comprehensive analysis and application of inductive reasoning assessment will expand the practical use of objective measurement in education and encourage other researchers to explore the assessment of creative thinking skills in different contexts.

Table 3. Summary of Rasch parameter for each indicator of creative thinking skills

Psychometrics attribute	Indicator				CT test
	FL	FE	E	O	
Number of items	3	3	3	3	12
Mean					
item outfit MNSQ	0.98	0.94	0.89	0.95	0.99
item Infit MNSQ	1.33	1.07	1.00	1.00	1.01
person outfit MNSQ	0.98	0.94	0.89	0.95	0.99
person Infit MNSQ	0.96	1.01	0.96	0.94	0.99
Item separation	2.58	5.01	1.86	0.00	3.65
Person separation	0.61	1.00	0.00	0.72	1.29
Unidimensionality					
Raw variance by measure	52.3%	63.1	29.1%	31.9%	53.9%
Unexplained variance first contrast	1.87	1.76	2.05	1.58	2.82

Reliability of Creative Thinking Test

The reliability criteria were examined using various indicators, such as Rasch parameters (Bond and Fox 2015; Boone 2016) and Cronbach's alpha (α) (Taber 2018). WINSTEPS program can calculate person dependability, item reliability, and Cronbach's Alpha (α). The Cronbach Alpha value, which shows the interaction between the person and the item, is 0.62, a sufficient level. Then, the person reliability value is 0.62 as an indicator of the consistency of the respondent's answer, which is acceptable. Item reliability is worth 0.93 as an indicator of the quality of the items in the instrument, which is an excellent category. Based on the Person Table, it can be seen that the average value of INFIT MNSQ is 0.99, and the OUTFIT MNSQ value is 0.99. Meanwhile, according to the Item Table, the average value of INFIT MNSQ is 1.02, and OUTFIT MNSQ is 0.99. If the provisions are closer to 1, it is better because the ideal value is 1. So that the average person and item are close to the ideal provisions, all the reliability results are summarised in Table 4.

Table 4. The result of the reliability test

	Standard Deviasi (SD)	*Reliability*	*Alpha Cronbach*
Person	0,13	0,62	0,62
Item	0,37	0,93	

Item difficulty categorization for the creative thinking skills test

Wright's map (Fig. 3) illustrates the interaction of objects and students. Wright's map shows that products and students meet the targeting requirements. In other words, each item is aimed at each student's ability. The category of difficulty level can be categorized based on the standard deviation in item size, as seen in Table 2. In this study, the standard deviation value is 1.24 logits. The results of this standard deviation are used to determine the categorization of items based on the standard deviation (Soeharto and Csapó 2022). The results of this standard deviation were used to determine the categorization of items based on Soeharto & Csapó (2022), where >+1SD (very difficult), 0.00 logit +1SD (difficult), 0.00 logit -1SD (easy), and <-1SD (easy). The results also show that some creative thinking skills test questions meet the fit standard based on the JMLE measure value, which ranges from 0.00 to 1.24 logits. Then, based on the category of difficulty level shows that the most difficult question is E2 (2.70 logits), while FE2, E1, E3, O1, O2, O3 are in the medium category (0.00-1.24 logits), easy questions are FL3 (-0.32 logits), and FL1, FL2, FE1, and FE3 questions (<-1.24) are the easiest.

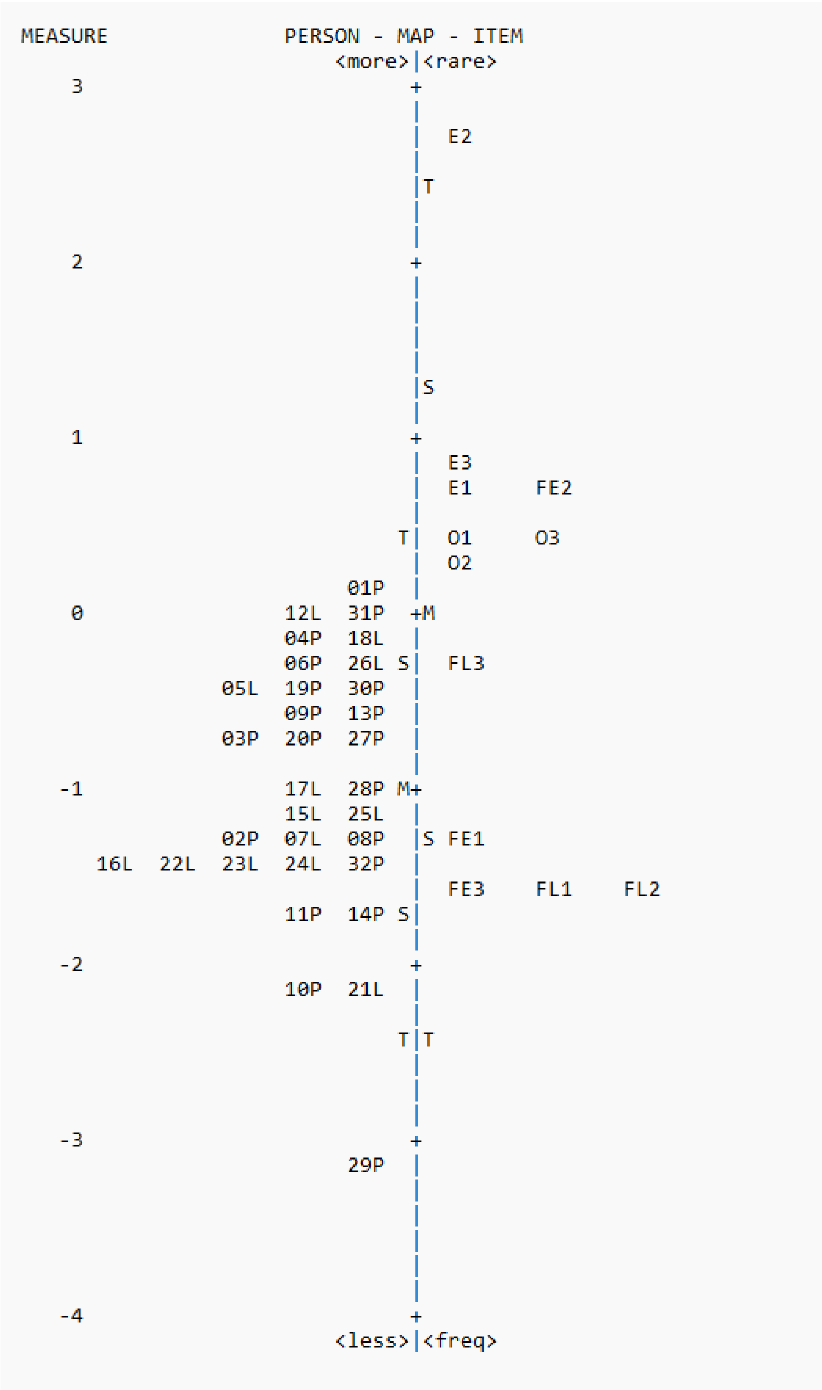

Figure 1. Wright map analysis

DIF Across Gender

In this investigation, the DIF analysis can also detect invariance issues. The DIF (Differential Item Functioning) analysis was employed to determine if any items exhibited gender bias (between women and men) that impacted critical thinking skills regarding the human digestive system. This analysis helps identify participant bias by subgroups or variables for each item in the instrument. Program 3.2 identified DIF across grade and gender using a significant probability ($p < 0.05$) and DIF size. The results of the DIF analysis based on gender can be seen in Figure 2.

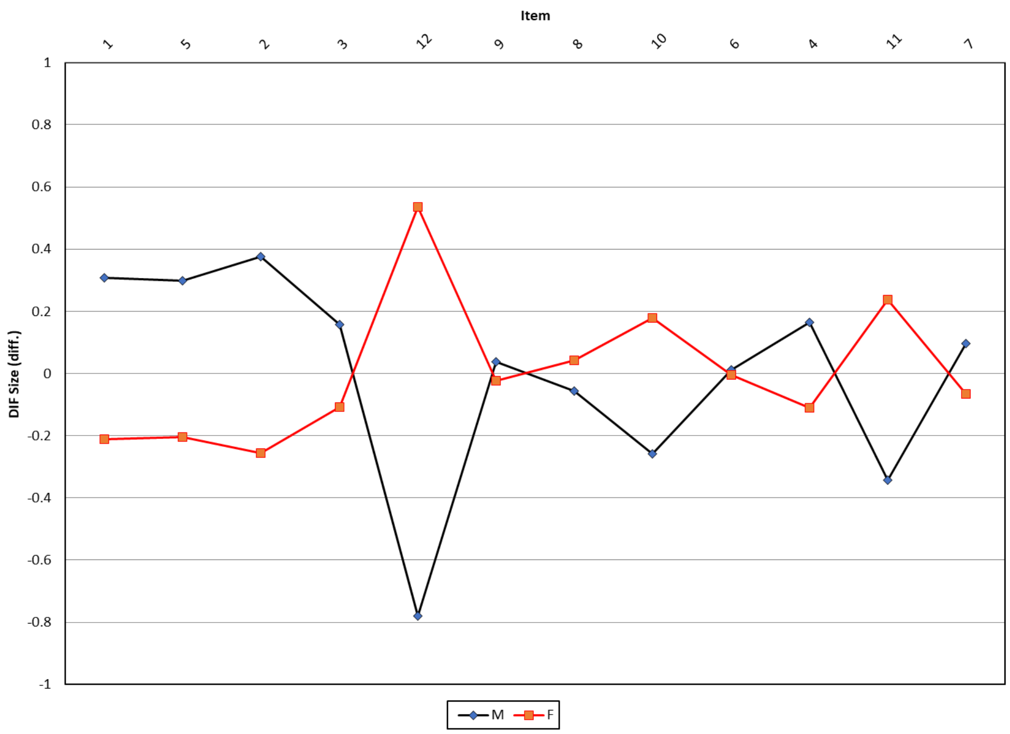

Figure 2. DIF analysis based on gender

Based on Figure 2. for two items, including FL3 (0.0325) and E3 (0.0006), we had p-values < 0.05 based on gender and DIF size. Therefore, there is an item bias between male and female students in these two items. This is in line with several studies that have used Rasch analysis to investigate gender bias in test item (Prasetya and Pratama 2023). Gender bias in indicators FL and E is caused by a lack of understanding of students' understanding of question instruction. For this reason, it is very important to compose narratives and choose words so that the resulting items or questions do not lead to different assumptions about gender so as not to cause gender bias.

CONCLUSION (5%)

This study provides insight into the impact of item-person interactions on tests of creative thinking skills. The adapted creative thinking skills test proved valid and reliable on solar cell material, indicating that this instrument can measure students' creative thinking skills. The test questions were proven to be free of bias; only FL3 and E3 questions had a p-value> 0.05, so these two questions were said to be biased. Although female students' creative thinking skills were better than male students, no significant gender differences were detected. Classification of item difficulty levels revealed various levels of difficulty, showing that the most difficult item was E2 (2.70 logits), while FE2, E1, E3, O1, O2, and O3 were in the medium category (0.00-1.24 logits), the easy item was FL3 (− 0.32 logit), and questions FL1, FL2, FE1, and FE3 (<-1.24) are the easiest.

The findings of this research offer preliminary data on the creative thinking skills of Indonesian students. This information can help teachers and researchers anticipate student success rates in disciplines other than mathematics and science. This is because the independent curriculum must include creative thinking skills. We believe creative thinking skills can be included and trained at all grade levels because they are high-level thinking skills for predicting students' academic progress. This study may be the first to use differentiated assessments and Rasch measurements to test students' creative thinking skills in Indonesia—in the form of recommendations for the next steps.

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