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Gender Roles in Understanding and Implementing Green Energy Technology in Indonesian Schools: Rasch Analysis

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ABSTRACT: This study aims to investigate gender differences in the understanding and application of green energy technology in schools in Indonesia. The method used is a survey with a questionnaire that covers aspects of knowledge attitudes readiness and obstacles related to green energy technology from a gender perspective. The sample of this study consisted of 829 teachers in various schools in Indonesia with a balanced distribution between male and female teachers. The data was analyzed using the Rasch measurement model with WINSTEPS 5.7.1 software to ensure the validity and reliability of the instrument. The results show that the instrument developed has good reliability and validity without significant item bias based on gender. The analysis shows that female teachers tend to have a higher understanding and application of green energy technology than male teachers. The ability distribution shows that most respondents are at a moderate to high level of ability in understanding and applying green energy technologies. These findings indicate the need for more inclusive and gender-sensitive education strategies to ensure all groups can contribute effectively to the implementation of green energy technologies in schools. The results of this study can be used as a basis for developing policy recommendations aimed at increasing equal involvement and understanding of green energy technologies among teachers both men and women. It is hoped that the gender gap in the understanding and application of green energy technology can be minimized and the application of this technology in schools can be improved.

Keywords: Gender, green energy, education, science teacher, Rasch analysis.

I. INTRODUCTION

Gender considerations are crucial in the application of green energy technology, especially in educational settings like schools in Indonesia. Promoting gender equality in education and energy technology is vital for sustainable development [1-4] . Analyzing energy access from a gender perspective provides valuable insights into how gender-based relationships affect energy needs and priorities within households [5-7] .

Green technology innovations play a significant role in improving environmental performance and achieving sustainability goals. These innovations help organizations enhance their environmental practices, meet stakeholder expectations, and facilitate a green energy transition [8-11] . Furthermore, green technology aims to conserve resources, reduce pollution, and drive economic, environmental, and social benefits [12-15]. The main issue addressed in this study is the difference in understanding and application of green energy technology between male and female teachers in Indonesian schools. Existing literature indicates that male teachers often have a higher understanding and application of green energy technology compared to female teachers.

To address this gap, more equitable training and education on green energy technologies are needed, along with policies that support gender participation in these areas. Programs that encourage the active participation of both genders in green energy technology education and training are expected to reduce this gap and improve the application of green energy technologies in schools [16, 17] .

Several specific solutions have been identified in the scientific literature to address the gender gap in understanding and applying green energy technologies. Co-creation behaviors in green supply chains can encourage wider participation and collaboration between men and women [18].

Green finance initiatives can support technological innovation and optimize industry structures, promoting energy-efficient practices and reducing emissions throughout the supply chain. These initiatives can be adapted to the education sector to support the development of gender-inclusive green energy technologies [19].

The importance of green technology innovation in new energy companies for revenue sustainability, supported by green finance development, highlights the need for policies and programs that support these innovations in schools. These can help reduce the gender gap and improve the understanding and application of green energy technologies among teachers [20-22] .

A review of the literature reveals a need for more specific research on the role of gender in understanding and applying green energy technologies in schools. Most current literature focuses on general contexts or industry sectors, with limited research on educational environments. Additionally, there are gaps in the literature regarding how training and education on green energy technologies can be tailored to increase equal engagement and understanding between male and female teachers. This study aims to fill this gap by exploring the gender differences in understanding and applying green energy technologies in Indonesian schools and identifying effective strategies to address these differences.

The purpose of this study is to investigate gender differences in understanding and applying green energy technology in Indonesian schools. The hypothesis states that there is a significant difference between male and female teachers in terms of understanding and application of green energy technology, with male teachers tending to have a higher level of understanding and application compared to female teachers.

The novelty of this study lies in its focus on the educational context in Indonesia, which has not been extensively explored in previous literature. Preliminary findings from the literature indicate gender differences in various aspects of green energy technology. This study investigates the factors influencing these differences and develops policy recommendations to increase equal engagement and understanding between male and female teachers in green energy technologies.

II. LITERATURE REVIEW

Research on the role of gender in understanding and implementing green energy technology in Indonesian schools is still relatively limited. However, a number of studies have revealed the importance of gender factors in the context of education and green technology. This literature review will discuss various findings from previous research related to green energy education, the role of gender in education, and challenges and opportunities in integrating green energy technologies in schools.

1. GREEN ENERGY EDUCATION IN SCHOOLS

Green energy education in schools is essential to form environmentally responsible citizens and foster a culture of sustainability. Various studies emphasize the importance of integrating sustainability education into school curricula to improve environmental knowledge, attitudes, and behaviors [23, 24] . Initiatives such as the Green-Schools program demonstrate the importance of instilling sustainable practices in students by involving them in caring for the environment within the school environment [25]. The implementation of the green school-based learning model has been proven to increase students' scientific literacy and contribute to creating environmentally conscious individuals [26]. Innovative teaching methods, such as mobile learning and digital transformation, offer new opportunities to create eco-friendly classrooms and promote green practices among teachers and students [27, 28] . Equipping teachers with green skills is essential for effectively integrating environmental education into vocational school curricula and promoting sustainable practices in the workplace [29]. In addition, the design of green school buildings not only improves environmental education but also contributes to creating a sustainable and energy-efficient learning environment [30, 31] .

2. THE ROLE OF GENDER IN IMPLEMENTING GREEN ENERGY TECHNOLOGIES

The role of gender is very significant in implementing green energy technologies, affecting various aspects in the renewable energy sector. Studies show that gender diversity in corporate boards can drive the adoption of renewable energy technologies in business, which has an impact on reducing air pollution and improving energy security [32]. Initiatives such as the Women in Solar Initiative aim to increase women's participation in the renewable energy industry [33]. Women's involvement in decision-making processes regarding renewable energy programs is essential to develop beneficial and inclusive initiatives [34]. In addition, research shows that women make up a significant part of the workforce in the renewable energy sector, especially in technical, policy, legal, and commercial roles [35]. However, there is still a need to address gender bias in renewable energy companies, as women often occupy non-technical positions despite the growing sector [36]. Interventions that aim to promote gender equality in renewable energy work are essential, especially in underserved communities [37].

3. RATING SCALE RASCH MODEL

The traditional methodology for evaluating data from rating scales, such as the Likert-type scale, is predicated on the assumption that each item within a questionnaire possesses uniform difficulty and that the incremental value between successive categories is consistent [38-41] . To illustrate, within a five-point Likert scale—ranging from "strongly disagree" (1) to "strongly agree" (5)—it is presumed that the value of the category "strongly agree" is quintuple that of "strongly disagree." Historically, researchers have treated ordinal data from rating scales as if they were interval data, aggregating the assigned values of each category to compute a total scale score [39]. This aggregate score is subsequently employed in statistical analyses to facilitate comparisons among respondents. However, Boone (2020), [39] emphasizes that it is erroneous to assume uniformity in the scale's unit increments or that all questionnaire items share the same difficulty level. This conventional method of data analysis disregards the inherent subjectivity within the data, operating under unfounded presumptions regarding the scale's nature [38, 42] . Consequently, such practices may culminate in invalid mathematical operations and compromise the efficacy of statistical analyses [43-46] .

The Rasch model's approach to analyzing rating scale data, particularly through the Rating Scale Model (RSM), challenges traditional perceptions. Unlike conventional methods that treat all items within a questionnaire as uniformly scalable based on difficulty, the Rasch model distinguishes items by their inherent difficulty levels. This differentiation means that each questionnaire item possesses a unique level of challenge for respondents, resulting in varied levels of agreement or disagreement across items. For instance, within a five-item questionnaire, the ease or difficulty of agreeing with the first item significantly differs from that of the fifth item. Moreover, the Rasch RSM methodologically assigns each category step, considering the ordinal nature of responses, recognizing that the progression from "strongly disagree" to "disagree" is qualitatively different from moving from "agree" to "strongly agree" on a Likert scale. This nuanced view extends to the labelling and coding of Likert scale responses ranging from "strongly disagree" (1) to "strongly agree" (5)—which are intended to delineate ordered categories rather than compute a cumulative score. Studies [38, 39] underscore that rating scale data inherently possess an ordinal quality, where the numeric values represent the sequence of responses rather than their quantitative measure, challenging the traditional aggregate scoring methods.

The Rating Scale Model (RSM), an advanced iteration of the original Rasch dichotomous model, was conceptualized by David Andrich in 1978. This model is tailor-made for the analysis of ordinal data emanating from fixed-step categories rating scales, such as the Likert-type scales commonly found in surveys and questionnaires. This refinement allows for a nuanced examination of data through the lens of Rasch's probabilistic model, offering insights into both respondent abilities and item difficulties within a unified interval measurement scale [46-50] .

At the heart of the RSM is the concept of logits, which are logarithmic odds that quantify the likelihood of a respondent moving from one category to the next within a rating scale. This model also introduces the critical notion of thresholds, delineating the transitions between consecutive rating categories and reflecting the inherent difficulty associated with each step [40]. For instance, a five-point Likert scale encompasses four thresholds, indicating the model's capacity to provide detailed insights into the scaling properties and the relative positioning of items and respondents on the latent trait being measured [51].

This mathematical framework does more than just analyze ordinal data; it transforms it into interval data, thereby overcoming one of the major limitations associated with traditional rating scales. This conversion is rooted in solid statistical evidence, illustrating the RSM's superiority in capturing the complexities of human responses more accurately and reliably than conventional methods [38]. Thus, the Rasch RSM not only enhances the validity and interpretability of ordinal data but also serves as a pivotal tool in the quantification of subjective perceptions and attitudes, elevating the precision and applicability of social science research. Hence, the RSM equation can be expressed as below:

$$P(X_{ni} = x) = \frac{exp \sum_{j=0}^{x} \left[\beta_n - \left(\delta_i + \tau_j\right)\right]}{\sum_{x=0}^{m} exp \sum_{j=0}^{x} \left[\beta_n - \left(\delta_i + \tau_j\right)\right]}, x = 0, 1, \dots, m \quad (1)$$

This formula contains three main parameters as follow:

β_n is the measure (ability) of person n,

δ_i is the difficulty of item i,

τ_i is the threshold parameters

Where $P(X_{ni} = x)$is the likelihood that an individual n is observed in the category x of the rating scale on item i, which comprises m + 1 rating scale categories, and

$$\sum_{j=0}^{0} \left[\beta_n - \left(\delta_i + \tau_j\right)\right] = 0 \quad (2)$$

The above equation describes the Rasch Rating Scale Model (RSM) as a quantification of the likelihood that an individual (denoted as 'n') with a given ability level (βn) will be observed choosing a given response category (x) on an item (i) characterized by a difficulty level (δi) [45, 52] . This model underscores the necessity of rigorous analysis of rating scales used in survey questionnaires to enhance the efficacy of scale categories and guarantee their appropriate functionality. The Rasch RSM emerges as the premier tool, favored for its simplicity and efficacy, in validating and refining the operational efficiency of rating scale categorization. This optimization process is pivotal for amplifying the precision of measurements [53]. Through this analytical lens, the Rasch RSM facilitates a more nuanced understanding and application of rating scale data, ensuring each category's validity and effectiveness in capturing respondents' abilities and item challenges.

4. RESEARCH QUESTION

This study aims to analyze the role of gender in understanding and implementing green energy technology in Indonesian schools. Using a survey approach, we collected data from teachers in various schools across Indonesia. The data were analyzed using the Rasch measurement approach through WINSTEPS 5.7.1 software [54]. The following four research questions were created to guide the study's objectives:

RQ1 : Does the developed instrument achieve reliability and validity based on Rasch measurement?

RQ2 : Is there any significant item bias detected based on gender using DIF analysis?

RQ3 : How is rating scale functioning of developed questionnaire in this study?

RQ4 : How do gender roles influence the understanding and implementation of green energy technology in Indonesian schools?

III. MATERIAL AND METHOD

This study used questionnaires as the primary tool to assess the understanding and implementation of green energy technology in schools across Indonesia. The questionnaire included questions focusing on knowledge, attitudes, and actions related to green energy from a gender perspective. Additionally, secondary literature from scientific journals, government reports, and publications from environmental organizations supported the data analysis.

The sample was randomly selected from various regions in Indonesia, considering the gender diversity of teachers and their involvement in environmental programs. Questionnaires were distributed to willing teachers, ensuring an equal number of male and female respondents to avoid gender bias.

The data collection involved distributing and collecting questionnaires over a specific period, conducted both directly and through online platforms to achieve broader participation. The collected data were analyzed using the Rasch measurement model with WINSTEPS 5.7.1 software to ensure the validity and reliability of the instruments used.

The measured parameters included understanding of green energy technology, the extent of its implementation in schools, and differences in perceptions and attitudes based on gender. Statistical analyses included the Rasch measurement model, t-tests to compare mean differences between gender groups, and ANOVA to identify significant differences among various school groups. All analyses were conducted using reliable statistical software to ensure the accuracy of the study results.

1. PARTICIPANT AND PROCEDURE

This study employed a quantitative approach using survey methods to collect data from teachers in various schools across Indonesia. A total of 829 Indonesian teachers voluntarily participated in the study by completing a questionnaire comprising four sections: knowledge about green energy (5 statements), attitudes towards green energy education (5 statements), readiness and support for adopting green energy education (5 statements), and barriers to adopting green energy education (5 statements). Each section used a five-point rating scale, ranging from 1 (never) to 5 (always). Data was collected through an online questionnaire tool.

The questionnaire was distributed via an online platform, Google Forms, allowing all teachers to participate in the study. All participants who met the criteria were included in our dataset without any additional exclusion criteria. Written consent was obtained from participants before they completed the questionnaire, and their responses were treated as confidential and anonymous. Participants were reached through teacher WhatsApp groups and were asked to complete the online questionnaire available in Indonesian. It was crucial for all participants to answer every question in the questionnaire without skipping any items. All measured variables are discussed in the present study as presented in Table 1. Education levels and living places were collected but will be analyzed and discussed in a different publication. In this study, we focused solely on investigating gender.

2. INSTRUMENTS

The green energy questionnaire consists of 20 items, with responses given on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The questionnaire is divided into four sections: knowledge about green energy (5 statements), attitudes towards green energy education (5 statements), readiness and support for adopting green energy education (5 statements), and barriers to adopting green energy education (5 statements).

The first section, KGE, represents teachers' knowledge about green energy, which includes understanding the differences between renewable and non-renewable energy sources, the impact of fossil fuel use on climate change and the environment, knowledge about various green energy technologies, government policies and regulations related to green energy, and the latest developments in green energy research and technology.

The second section, ATGE, focuses on teachers' attitudes towards green energy education. This includes the belief that integrating green energy education can increase environmental awareness, motivation to actively incorporate green energy topics into science teaching materials in schools, the important role in transitioning towards a sustainable society, support for the use of green energy-based projects and experiments in the classroom, and the view that green energy education should be a mandatory component of the school curriculum.

The third section, RSAGE, relates to the readiness and support for adopting green energy education. This includes having sufficient resources (e.g., learning materials, teaching aids) to teach green energy topics, feeling comfortable and confident in delivering green energy material, attending training or workshops related to green energy teaching, having access to networks or communities of teachers also interested in green energy education, and the ability to integrate green energy education with other subjects.

The final section, BAGE, relates to the barriers in adopting green energy education. These barriers include a lack of time to prepare green energy lesson materials, difficulty finding relevant and up-to-date learning resources, a lack of support from the school administration, concerns that students may not be interested in green energy topics, and a crowded curriculum that makes it difficult to integrate new topics like green energy.

3. DATA ANALYSIS

WINSTEPS version 5.7.1 software [54] was employed for Rasch analysis using joint maximum likelihood estimation (JMLE) to conduct psychometric evaluations and ratings. This study utilized Rasch modeling to transform student scores into interval data (logits) that span from negative to positive infinity.

To investigate the measurement properties of the Green Energy questionnaire, several Rasch indicators were examined, including unidimensionality, local independence, item and person separation, item reliability, and fit validity based on infit and outfit mean MNSQ values. Unidimensionality was confirmed by ensuring the raw variance values by measures exceeded 30%, and the unexplained variance of the first contrast remained below 2 [55]. Yen's Q3 statistic [56] was used to verify local independence, aiming for a raw residual correlation below 0.4. Item and person separation values needed to exceed 2 logits to indicate distinct group levels within the dataset [57]. Item reliability and Cronbach's alpha (α) values were required to be above 0.6 to ensure the study's reliability [58, 59] . Fit validity was assessed using infit and outfit mean MNSQ values, with an acceptable range from 0.5 to 1.5, though values up to 1.6 were considered acceptable if the point measure correlation (PTMA) remained positive [60].

An item-person map was created to validate the interaction between items and individuals. ICC plots were used to ensure item fit validity at the instrument level. Gender-based DIF analysis was conducted to identify bias interactions for each item. Additionally, a histogram with logit measures using R statistics was utilized to compare the role of gender in understanding and implementing environmentally friendly energy technology in Indonesian schools.

IV. RESULT

The data analysis section is crucial in this research, detailing the systematic processes used to interpret, organize, and derive insights from the data. Analysis begins with the Rasch measurement model to ensure survey instrument validity and reliability, chosen for its ability to convert ordinal data to interval data for more accurate statistical analysis. Data is analyzed using WINSTEPS 5.7.1 software, which performs in-depth analysis, including reliability calculations and identifying biased items. T-tests and ANOVA compare mean differences between male and female groups in understanding and applying green energy technology, while linear regression evaluates the impact of independent variables on dependent ones. Transparent documentation of these procedures enhances the rigor and credibility of the findings, offering a clear understanding of data processing and interpretation. This systematic approach provides deeper insights into gender differences and factors influencing them, aiding in developing precise policy recommendations for equal engagement in green energy technologies.

Table 1. Demographic profiles of science teachers in this study

Demographic		Frequency	Percentage (%)
Education qualification	undergraduate	618	74,60%
	Master's	202	24,34%
	Doctor	9	1,06%
Education Level	Elementary School	73	8,81%
	Junior High School	640	77,20%
	Senior High School	116	13,99%
Teaching experience	0– 5 years	70	8,46%
	6– 10 years	92	11,11%
	11– 15 years	215	25,93%
	16– 20 years	250	30,16%
	>20 years	202	24,34%
Gender	Female	567	68,40%
	Male	262	31,60%
School Location	Rural	566	68,28%
	Urban	263	31,72%

1. VALIDITY AND REALIBILITY OF THE GREEN ENERGY QUISIONER (RQ1)

1.1 Validity

To confirm the validity of the Green Energy Questionnaire, the item and person parameters produced using Rasch analysis were assessed with the infit and outfit MNSQ as presented in Table 2. The infit and outfit MNSQ values indicate that items and persons achieved the fit validity criteria. Since this study has a large sample size of more than 500 students, the infit and outfit z-standardized (ZSTD) values can be ignored as a threshold for fit validity criteria [61]. The separation values for items and persons should be greater than 2 logits to confirm that there are more than two different groups in terms of individual ability and item difficulty level. Table 2 shows the summary of Rasch parameters for the Green Energy Questionnaire, indicating that both person and item levels achieved the fit validity criteria based on MNSQ values ranging from 1.00 to 1.06. The item and person separation values also exceed 2 logits. The construct validity of the Green Energy Questionnaire was confirmed by assessing the instrument's unidimensionality and local independence. The raw variance values in Table 2 confirm that unidimensionality was attained in both studies.

Table 2. Summary of Rasch Parameters for Green Energy Questionnaire

Psychometrics Attribute	Subscale				Green Energy Questionnaire
	KGE	ATGE	RSAGE	BAGE	
Number of Items	5	5	5	5	20
Mean	19,9	21,9	16,3	15,2	73,6
item outfit MNSQ	0,98	0.97	1,00	0,98	0,99
item infit MNSQ	1,02	0,97	0,99	1,00	0,99
Person outfit MNSQ	0,98	0,97	1,00	0,98	0,99
Person infit MNSQ	0,97	0,94	1,01	1,00	1,03
Item separation	19,85	9,43	16,00	7,48	21,79
Person separation	1,75	1,72	1,41	1,92	2,02
Item Reliability	1,00	0,99	1,00	0,98	1,00
Cronbach's Alpha	0,78	0,86	0,66	0,80	0,81
Unidimensionality					
Raw variance explained by measure	60,2%	53,6%	51,9%	54,1%	
Unexplained variance 1st contrast	18,2%	15,2%	20,1%	16,1%	

The summary in Table 2 shows the Rasch parameters for the Green Energy Questionnaire, demonstrating good reliability and validity across all subscales (KGE, ATGE, RSAGE, BAGE). The high item separation values indicate that the questionnaire can distinguish between different levels of respondent ability effectively. This supports the robustness of the questionnaire in measuring teachers' understanding and implementation of green energy technology

Table 3 provides item measures and fit criteria, showing that all items fall within the acceptable Outfit MNSQ range of 0.75 to 1.34, which indicates a good fit according to the Rasch model. The item measures range from 1.75 logits to 1.66 logits, confirming the validity of each item in the questionnaire. This suggests that the questionnaire items are well-calibrated to assess the intended constructs without significant bias.

An item-person map (Figure 1) is used to illustrate the interaction between items and respondents. On the left side of the map, respondents with higher abilities are positioned at the top, while those with lower abilities are at the bottom. Most respondents are clustered around the logit value of 1, indicating a generally good ability to understand and assess green energy topics. A few respondents with very high abilities (above logit value of 4) and very low abilities (below logit value of -1) are also present.

On the right side of the map, items with higher difficulty are located at the top, and those with lower difficulty are at the bottom. Items such as RSAGE14, BAGE16, BAGE17, BAGE18, and BAGE19, which are around logit values of 1-2, are somewhat challenging for the average respondent. Meanwhile, items like KGE1, KGE2, ATGE6, ATGE7, ATGE8, and ATGE9, which are below logit value of 0, are relatively easy for the respondents. This balance suggests that the questionnaire items are appropriately challenging for the target population.

The Wright Map provides a clear picture of the alignment between respondent abilities and item difficulty, essential for evaluating the questionnaire and developing more effective measurement instruments in the future. It indicates that while most respondents have adequate abilities to understand and assess green energy topics, some items may require revision to ensure better comprehension across all ability levels.

From this analysis, it can be concluded that the Green Energy Questionnaire has a fairly balanced distribution of items relative to respondent abilities. However, some items may need revision or further attention to ensure all respondents can understand them well. Most respondents have adequate abilities to understand and assess the topic of green energy, suggesting they tend to have sufficient knowledge or interest in this field. Thus, the Wright Map provides a clear picture of the alignment between respondent abilities and item difficulty, which is crucial for evaluating the questionnaire and developing more effective measurement instruments in the future.

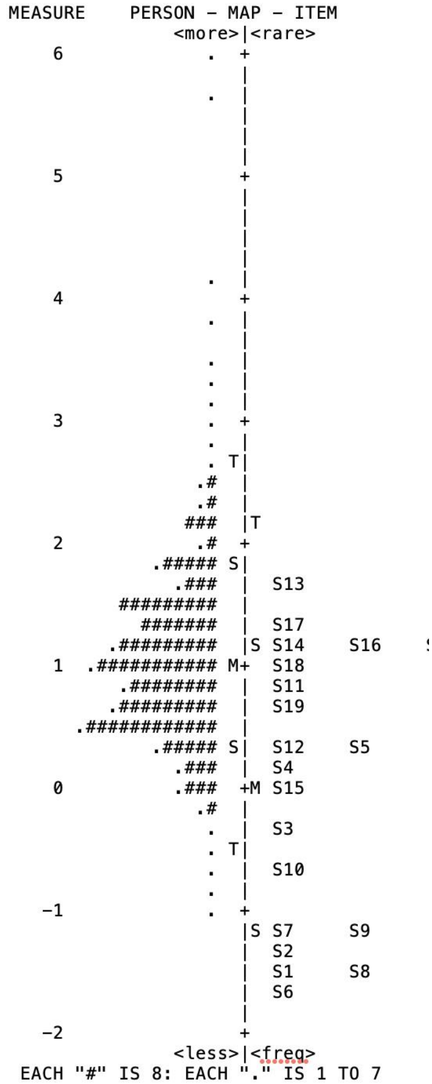

FIGURE 1. Item-person maps. Note: (#),8 participants, (.) 1–7 participants.

Table 3. Item Measure and Fit Criteria

Item Number	Measure (logit)	Outfit MNSQ	PTMA
KGE1	-1,50	1,19	0,38
KGE2	-1,31	0,89	0,41
KGE3	-0,36	0,80	0,47
KGE4	0,16	0,83	0,49
KGE5	0,31	0,86	0,51
ATGE6	-1,75	0,75	0,46
ATGE7	-1,25	0,75	0,53
ATGE8	-1,48	0,84	0,44
ATGE9	-1,23	0,82	0,45

Item Number	Measure (logit)	Outfit MNSQ	PTMA
ATGE10	-0,68	1,06	0,48
RSAGE11	0,76	1,06	0,46
RSAGE12	0,25	1,34	0,43
RSAGE13	1,66	1,12	0,49
RSAGE14	1,19	1,11	0,52
RSAGE15	-0,04	0,99	0,42
BAGE16	1,19	0,91	0,50
BAGE17	1,34	0,89	0,54
BAGE18	1,01	1,14	0,43
BAGE19	0,62	1,28	0,37
BAGE20	1,09	1,26	0,42

1.2 Reliability

The reliability criteria for items were determined using Cronbach's alpha (α) for all items in the green energy questionnaire and for each dimension (see Table 2). The item reliability values ranged from 0.98 to 1.00, confirming the reliability of the items for both studies [58]. Cronbach's alpha (α) values ranged from 0.66 to 0.86, with 0.6 as the minimum threshold [59]. Based on Cronbach's alpha values, these results indicate that reliability was also achieved.

2. DIF ANALYSIS BASED ON GENDER (RQ2)

DIF analysis is used to determine whether items exhibit gender bias (female and male) that could affect pre-service primary teachers' reading strategy abilities. This analysis can identify participant bias at the item level in the questionnaire based on subgroups or background variables [42, 62] . DIF results are calculated using two criteria: significant probability ($p < 0.05$) and DIF contrast. There are three DIF contrast classifications used [63]: negligible (|DIF| < 0.43 logits), slight to moderate (|DIF| ≥ 0.43 logits), and moderate to large (|DIF| ≥ 0.64 logits). Figure 2 shows the DIF size based on significant probability for several items in both studies. However, no items have a DIF contrast greater than 0.43 logits. Therefore, it can be concluded that all items have negligible DIF, indicating that the instrument does not have gender bias issues.

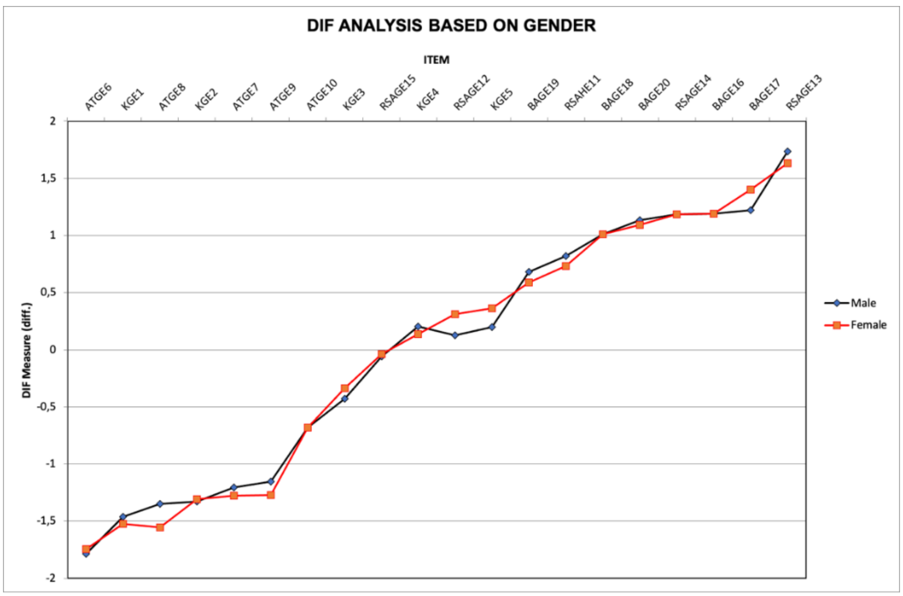

FIGURE 2. DIF Analysis Based on Gender

The graph Figure 2 "DIF Analysis Based on Gender" displays the Differential Item Functioning (DIF) analysis based on gender (male and female) for various items in the green energy questionnaire. This analysis aims to determine whether any items in the questionnaire show gender bias, which could affect the research results.

Based on the two criteria used in the DIF analysis, namely significant probability ($p < 0.05$) and DIF contrast/size, there are three DIF size classifications used [63]:

- Category A: Negligible (|DIF| < 0.43 logits)
- Category B: Slight to moderate (|DIF| ≥ 0.43 logits)
- Category C: Moderate to large (|DIF| ≥ 0.64 logits)

From the graph, we can see that most items fall within the negligible DIF range (|DIF| < 0.43 logits). No item has a DIF size greater than 0.43 logits, meaning all items in this questionnaire fall into Category A, indicating that these items do not exhibit significant gender bias.

Specifically, the DIF values for items such as ATGE6, KGE1, ATGE8, KGE2, ATGE9, ATGE7, ATGE10, KGE3, RSAGE15, KGE4, RSAGE12, KGE5, RSAGE11, BAGE19, BAGE18, BAGE20, RSAGE14, BAGE16, BAGE17, and RSAGE13 are all below the threshold of 0.43 logits. This indicates that there are no significant differences between male and female respondents in their responses to these items.

Thus, it can be concluded that the green energy questionnaire does not have gender bias issues, making it valid for use in research involving respondents of both genders. This interpretation reinforces the reliability of the questionnaire in measuring the understanding and implementation of green energy technology without gender bias.

3. RATING SCALE CATEGORY FUNCTIONING

The function of the 5-point rating scale in the green energy questionnaire is used to assess how well respondents understand the scale. The category probability curve in Figure 3 illustrates the performance of the 5-point scale in the questionnaire.

Table 4. Rating Scale Functioning

Category label	Observed		Observed average	INFIT MNSQ	OUTFIT MNSQ	Andrich Threshold
	Count	%				
1	482	3	-0.54	1.18	1.21	NONE
2	2397	14	-0.25	1.06	1.08	−2.10
3	3020	18	0.28	0.91	0.87	−0.21
4	6689	40	1.25	0.96	0.92	-0.01
5	3986	24	2.36	1.02	1.00	2.32

Table 4 provides a summary of the rating scale functioning for the Rasch model with five categories. This rating scale is used to assess how well respondents understand and use the scale in the green energy questionnaire.

From the table, we can see the number of observations and the total response percentage for each category. Category 1 has 482 responses (3%), category 2 has 2397 responses (14%), category 3 has 3020 responses (18%), category 4 has 6689 responses (40%), and category 5 has 3986 responses (24%). This indicates that all categories have been used adequately by respondents, with category 4 being the most frequently used.

The average measure (logit value) for respondents in each category increases gradually from category 1 to category 5, indicating that the categories function as expected. These average values are -0.54 for category 1, -0.25 for category 2, 0.28 for category 3, 1.25 for category 4, and 2.36 for category 5.

The Mean Square Infit and Outfit statistics for each category show the data's fit to the Rasch model. Most categories have Infit and Outfit MNSQ values close to 1.0, indicating good fit. For instance, category 1 has an Infit value of 1.18 and an Outfit value of 1.21, which are slightly higher but still acceptable. The other categories have Infit and Outfit values ranging from 0.87 to 1.08, all within the acceptable range.

The Andrich thresholds between categories indicate that these thresholds are correctly ordered, although there is a slight negative threshold between categories 4 and 5 that should be monitored. These thresholds are -2.10 between categories 2 and 3, -0.21 between categories 3 and 4, -0.01 between categories 4 and 5, and 2.32 between category 5 and the end.

Overall, the rating scale for the green energy questionnaire shows good functioning across all categories, with appropriate usage and good fit statistics. This supports the validity and reliability of the scale in this context, ensuring that the rating scale can be used effectively to measure the understanding and implementation of green energy technology without bias.

```
        CATEGORY PROBABILITIES: MODES - Andrich thresholds at intersections
P      -+------+------+------+------+------+------+------+------+-
R  1.0 +                                                         +
O      |                                                         |
B      |                                                         |
A      |111                                                     5|
B   .8 +   11                                                 55 +
I      |     11                                             55   |
L      |       1                                          55     |
I      |        11                                       5       |
T   .6 +          1                            4444       55     +
Y      |           1      222               444    444   5       |
    .5 +            1 222    222           4          445        +
O      |            2*1         22        4           554        |
F   .4 +           2   1          2    44           5    44      +
       |         22     1          *3*            5        44    |
R      |       22        1       333 * 3333     55           4   |
E      |     22           11 33   4 22    33   5              44 |
S   .2 +   22               3*    4    2    3*5                444 +
P      |222                33  1144       22 55 33                4|
O      |                 333    4411        5*2     333            |
N      |          33333   4444     111*555    2222   333333        |
S   .0 +*****************55555555555 1111111111*****************+
E      -+------+------+------+------+------+------+------+------+-
       -4     -3     -2     -1      0      1      2      3      4
        PERSON [MINUS] ITEM MEASURE
```

FIGURE 3. Rating Scale Functioning

The "CATEGORY PROBABILITIES: MODES - Andrich thresholds at intersections" graph (Figure 3) displays the category probability curves for the Rasch model rating scale. This graph is useful for understanding how respondents choose categories in the rating scale and ensuring that these categories function properly. On the X-axis, the graph shows the difference between individual ability and item difficulty, with values ranging from -4 to 4. Negative values indicate that the individual's ability is lower than the item's difficulty, while positive values indicate that the individual's ability is higher than the item's difficulty. Meanwhile, the Y-axis represents the probability of response, ranging from 0 to 1.0, showing the likelihood that a respondent will choose a specific category on the rating scale.

The probability curves for each category (1, 2, 3, 4, 5) indicate the likelihood that each category will be chosen based on the individual's ability relative to the item's difficulty. Andrich thresholds are shown at the points where the probability curves for two categories intersect, helping to ensure that each step in the rating scale represents a consistent increase in the measured attribute. The probability of choosing category 1 is high when the individual's ability is much lower than the item's difficulty, while categories 2, 3, 4, and 5 each reach their peak probabilities at progressively higher ability levels. The orderly Andrich thresholds indicate that the rating scale functions well without any irregularities. Overall, this graph shows that the 5-point rating scale in the green energy questionnaire functions effectively, with each category clearly defined and used appropriately based on respondents' abilities relative to item difficulty. This supports the validity and reliability of the rating scale in measuring understanding and implementation of green energy technology.

Evaluation of Gender Roles in Understanding and Implementing Green Energy Technologies in Indonesian Schools

4. EVALUATION OF GENDER ROLES IN UNDERSTANDING AND IMPLEMENTING GREEN ENERGY TECHNOLOGIES IN INDONESIAN SCHOOLS (RQ4)

R statistics integrated into the WINSTEPS software were used to determine the abilities of pre-service primary school teachers and create a histogram for both studies Figure 4.

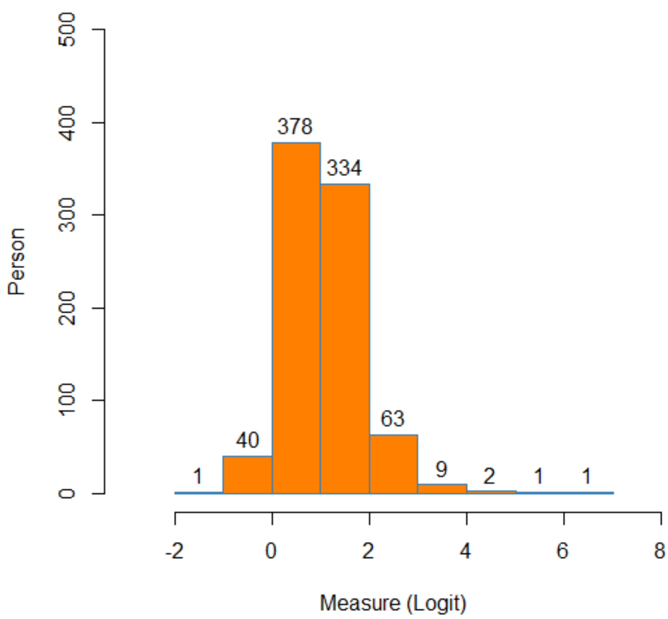

FIGURE 4. Gender roles in understanding and implementing green energy technologies in Indonesian schools

The histogram Figure 4 shows the distribution of abilities (measured in logits) among respondents. Most respondents have logit abilities ranging from 0 to 2, with peak distributions at logit values of 0 and 1, occupied by 378 and 334 respondents, respectively. This indicates that most respondents have moderate to high abilities. Few respondents fall below a logit value of 0 or above a logit value of 4, suggesting a concentration of abilities around the moderate to high range. This ability distribution supports the finding that most teachers have a sufficient understanding and ability to implement green energy technology in schools.

This histogram analysis can provide insights into how gender roles influence the understanding and implementation of green energy technology in Indonesian schools. If the abilities measured in logits are related to understanding green energy technology, we can further examine whether there are significant differences between male and female abilities in comprehending and implementing this technology. For example, if the logit distribution shows significant differences between genders in high or very high ability groups, this may indicate a gender role that affects the success of green energy technology implementation in schools. Consequently, these results can help formulate more inclusive and effective educational strategies for teaching green energy technology, considering the role of gender in the learning and implementation process.

Table 5. LVP analysis Gender roles in understanding and implementing green energy technologies in Indonesian schools

Demographics	Very high, LVP > Mean Logit + 2SD	High, Mean Logit + 2 SD ≥ LVP ≥ Mean Logit	Moderate, Mean Logit ≤ LVP ≤ Mean Logit – 2 SD	Low, LVP < Mean Logit – SD
Gender				
Male	5	129	119	9
Female	16	265	276	10
Total	21	394	395	19

Table 5 depicts the distribution of abilities (Logit Value Points/LVP) of science teachers based on gender in four categories: very high, high, moderate, and low. These categories are determined based on the mean logit value and standard deviation (SD). From the table, we can see that out of a total of 21 respondents with very high abilities (LVP > Mean Logit + 2SD), 16 are female and only 5 are male. In the high ability category (Mean Logit + 2 SD ≥ LVP ≥ Mean Logit), there are 394 respondents with 265 females and 129 males. In the moderate ability category (Mean Logit ≤ LVP ≤ Mean Logit - 2 SD), there are 395 respondents with 276 females and 119 males. Lastly, in the low ability category (LVP < Mean Logit - 2 SD), there are 19 respondents with 10 females and 9 males.

This table shows that females tend to have higher abilities in understanding and implementing green energy technology compared to males. This can be interpreted as gender roles potentially influencing how individuals comprehend and apply this technology in Indonesian schools. The higher number of females in the very high and high ability categories suggests that they might be more open or encouraged to understand and adopt green energy technology. On the other hand, the higher proportion of males in the moderate and low ability categories indicates a need for more inclusive and gender-sensitive educational strategies. These strategies could include specialized training, mentoring programs, or policies that encourage active male participation in green technology, ensuring that all groups can contribute effectively to the implementation of green energy technology in schools.

V. CONCLUSION

This study used questionnaires as the primary tool to assess the understanding and implementation of green energy technology in schools across Indonesia. The questionnaire included questions focusing on knowledge, attitudes, and actions related to green energy from a gender perspective. Additionally, secondary literature from scientific journals, government reports, and publications from environmental organizations supported the data analysis.

The sample was randomly selected from various regions in Indonesia, considering the gender diversity of teachers and their involvement in environmental programs. Questionnaires were distributed to willing teachers, ensuring an equal number of male and female respondents to avoid gender bias.

The data collection involved distributing and collecting questionnaires over a specific period, conducted both directly and through online platforms to achieve broader participation. The collected data were analyzed using the Rasch measurement model with WINSTEPS 5.7.1 software to ensure the validity and reliability of the instruments used.

The measured parameters included understanding of green energy technology, the extent of its implementation in schools, and differences in perceptions and attitudes based on gender. Statistical analyses included the Rasch measurement model, t-tests to compare mean differences between gender groups, and ANOVA to identify significant differences among various school groups. All analyses were conducted using reliable statistical software to ensure the accuracy of the study results.

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Author contribution

All authors made an equal contribution to the development and planning of the study.

Data Availability Statement

Data are available from the authors upon request.

Conflict of Interest

The authors have no potential conflicts of interest, or such divergences linked with this research study.

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REFERENCES

1. Perlaviciute, G., Steg, L., & Sovacool, B. K. (**2021**). A perspective on the human dimensions of a transition to net-zero energy systems. *Energy Climate Change*, *2*, 10004.
2. Baruah, B., & Gaudet, C. (**2022**). Creating and optimizing employment opportunities for women in the clean energy sector in Canada. *Journal of Canadian Studies*, *56*(2), 240–270.
3. Bray, R., Montero, A. M., & Ford, R. (**2022**). Skills deployment for a 'just' net zero energy transition. *Environmental Innovation and Societal Transitions*, *42*, 395–410.
4. Mininni, G., & Hiteva, R. (**2023**). Place-based solutions for net zero: Gender considerations on 'green' skills. *Proceedings of the International Conference on Gender Research*, *2023-April*, 185–191.
5. Kooijman, A., Clancy, J., & Cloke, J. (**2023**). Extending energy access assessment: The added value of taking a gender perspective. *Energy Research & Social Science*, *96*, 102923.
6. Das, I., et al. (**2023**). Frameworks, methods and evidence connecting modern domestic energy services and gender empowerment. *Nature Energy*, *8*(5), 435–449.
7. Pearl-Martinez, R. (**2020**). Global trends impacting gender equality in energy access. *IDS Bulletin*, *51*(1).
8. Zhang, F., & Zhu, L. (**2019**). Enhancing corporate sustainable development: Stakeholder pressures, organizational learning, and green innovation. *Business Strategy and the Environment*, *28*(6), 1012–1026.
9. Song, W., Wang, G., & Ma, X. (**2020**). Environmental innovation practices and green product innovation performance: A perspective from organizational climate. *Sustainable Development*, *28*(1), 224–234.
10. Cui, R., & Wang, J. (**2022**). Shaping sustainable development: External environmental pressure, exploratory green learning, and radical green innovation. *Corporate Social Responsibility and Environmental Management*, *29*(3), 481–495.
11. Tu, Y., & Wu, W. (**2021**). How does green innovation improve enterprises' competitive advantage? The role of organizational learning. *Sustainable Production and Consumption*, *26*, 504–516.
12. Wang, M., Li, Y., & Liao, G. (**2021**). Research on the impact of green technology innovation on energy total factor productivity, based on provincial data of China. *Frontiers in Environmental Science*, *9*.
13. Su, T., Chen, Y., & Lin, B. (**2023**). Uncovering the role of renewable energy innovation in China's low carbon transition: Evidence from total-factor carbon productivity. *Environmental Impact Assessment Review*, *101*, 107128.
14. Wang, J., Dong, X., & Dong, K. (**2023**). Does renewable energy technological innovation matter for green total factor productivity? Empirical evidence from Chinese provinces. *Sustainable Energy Technologies and Assessments*, *55*, 102966.
15. Li, G., Gao, D., & Li, Y. (**2022**). Dynamic environmental regulation threshold effect of technical progress on green total factor energy efficiency: Evidence from China. *Environmental Science and Pollution Research*, *29*(6), 8804–8815.
16. Yeolekar-Kadam, B., & S., S. J. (**2022**). Feasibility study on integration of green technologies in prospective construction projects: A case of Vishakhapatnam. *International Journal of Management Technology and Social Sciences*, *7*(1), 210–223.

17. Wang, F. (**2021**). The application of green energy-saving technology in building design—Take Zhejiang Water Control Museum architectural design as an example. *IOP Conference Series: Earth and Environmental Science*, *787*(1), 12075.
18. Shi, X., Li, G., Dong, C., & Yang, Y. (**2020**). Value co-creation behavior in green supply chains: An empirical study. *Energies*, *13*(15).
19. Xie, M., Zhao, S., & Lv, K. (**2024**). The impact of green finance and financial technology on regional green energy technological innovation based on the dual machine learning and spatial econometric models. *Energies*, *17*(11).
20. Zhu, W., & Zou, J. (**2022**). The impact of green technology innovation of new energy companies on earnings sustainability in China—Based on the regulatory effect of green finance development. *American Journal of Industrial and Business Management*, *12*(08), 1348–1362.
21. Li, H., Chen, C., & Umair, M. (**2023**). Green finance, enterprise energy efficiency, and green total factor productivity: Evidence from China. *Sustainability*, *15*(14), 11065.
22. Jiang, S., Liu, X., Liu, Z., Shi, H., & Xu, H. (**2022**). Does green finance promote enterprises' green technology innovation in China? *Frontiers in Environmental Science*, *10*, 981013.
23. Maurer, M., Koulouris, P., & Bogner, F. X. (**2020**). Green awareness in action—How energy conservation action forces on environmental knowledge, values, and behaviour in adolescents' school life. *Sustainability*, *12*(3).
24. Zelenika, I., Moreau, T., Lane, O., & Zhao, J. (**2018**). Sustainability education in a botanical garden promotes environmental knowledge, attitudes, and willingness to act. *Environmental Education Research*, *24*(11), 1581–1596.
25. O'Neill, C., & Buckley, J. (**2019**). 'Mum, did you just leave that tap running?!' The role of positive pester power in prompting sustainable consumption. *International Journal of Consumer Studies*, *43*(3), 253–262.
26. Herlina, W., Hidayat, T., & Rahman, T. (**2022**). The effect of green school-based inquiry learning model on students' ability of scientific literacy. *Jurnal Penelitian Pendidikan IPA*, *8*(5 SE-Research Articles), 2513–2517.
27. Hoque, F., Yasin, R. M., & Sopian, K. (**2023**). Mobile learning to promote renewable energy education at the secondary education level in developing countries. *IOP Conference Series: Materials Science and Engineering*, *1278*(1), 12017.
28. Qiu, Y., Chen, Q., & Ng, P. S. J. (**2023**). Research on the spillover effects of digital transformation on the sustainable growth of green schools. *Proceedings of Business and Economics Studies*, *6*(6), 16–23.
29. Handayani, M. N., Ali, M., Wahyudin, D., & Mukhidin. (**2020**). Green skills understanding of agricultural vocational school teachers around West Java, Indonesia. *Indonesian Journal of Science and Technology*, *5*(1), 21–30.
30. Cole, L. B., & Hamilton, E. M. (**2019**). Can a green school building teach? A pre- and post-occupancy evaluation of a teaching green school building. *Environmental Behavior*, *52*(10), 1047–1078.
31. Sagala, A. F., & Pane, I. F. (**2021**). The design of boarding school in Simanindo, Samosir (green architecture). *International Journal of Architecture and Urbanism*, *5*(3), 375–386.
32. Issa, A. (**2023**). Shaping a sustainable future: The impact of board gender diversity on clean energy use and the moderating role of environmental, social, and governance controversies. *Corporate Social Responsibility and Environmental Management*, *30*(6), 2731–2746.
33. Lazoroska, D., Palm, J., & Bergek, A. (**2021**). Perceptions of participation and the role of gender for the engagement in solar energy communities in Sweden. *Energy for Sustainable Societies*, *11*(1), 35.
34. Oluoch, S., Lal, P., Susaeta, A., Mugabo, R., Masozera, M., & Aridi, J. (**2022**). Public preferences for renewable energy options: A choice experiment in Rwanda. *Frontiers in Climate*, *4*(May), 1–12.
35. Khaemba, W., & Kingiri, A. (**2020**). Access to renewable energy resources: A gender and inclusivity perspective. In W. Leal Filho, A. M. Azul, L. Brandli, A. Lange Salvia, & T. Wall (Eds.), *Affordable and Clean Energy* (pp. 1–10). Springer International Publishing.
36. Arias, K., et al. (**2023**). Green transition and gender bias: An analysis of renewable energy generation companies in Latin America. *Energy Research & Social Science*, *101*(July).
37. Baruah, B. (**2017**). Renewable inequity? Women's employment in clean energy in industrialized, emerging and developing economies. *Natural Resources Forum*, *41*(1), 18–29.
38. Bond, T. G., & Fox, C. M. (**2015**). *Applying the Rasch Model: Fundamental Measurement in the Human Sciences* (3rd ed.). Routledge.
39. Boone, W. J. (**2020**). Rasch basics for the novice. *Rasch Measurement Applications*, *Quantitative Educational Research*, 9–30.
40. DiStefano, C., & Jiang, N. (**2020**). Applying the Rasch rating scale method to questionnaire data. *Rasch Measurement Applications*, *Quantitative Educational Research*, 31–46.
41. Soeharto, S., et al. (**2024**). The metacognitive awareness of reading strategy among pre-service primary teachers and the possibility of rating improvement using Rasch analysis. *Studies in Educational Evaluation*, *80*(December).
42. Boone, W., Staver, J., & Yale, M. (**2014**). *Rasch Analysis in the Human Sciences*. Springer.
43. Merbitz, C., Morris, J., & Grip, J. C. (**1989**). Ordinal scales and foundations of misinference. *Archives of Physical Medicine and Rehabilitation*, *70*(4), 308–312.
44. Wright, B. D., & Linacre, J. M. (**1989**). Observations are always ordinal; measurements, however, must be interval. *Archives of Physical Medicine and Rehabilitation*, *70*(12), 857–860.
45. S. E. Mokshein, H. Ishak, & H. Ahmad. (**2003**). Optimizing rating scales for self-efficacy (and other) research. *Journal*, *63*(3).
46. Mokshein, S. E., Ishak, H., & Ahmad, H. (**2019**). The use of Rasch measurement model in English testing. *Jurnal Cakrawala Pendidik*, *38*(1), 16–32.
47. Wright, B. D., & Masters, G. N. (**1982**). *Rating Scale Analysis*. MESA Press.
48. Linacre, J. M. (**2000**). Comparing 'partial credit' and 'rating scale' models. *Rasch Measurement Transactions*, *14*(3), 768.
49. Dimitrov, D. M. (**2014**). *Statistical Methods for Validation of Assessment Scale Data in Counseling and Related Fields*. John Wiley & Sons.
50. Engelhard Jr, G., & Wind, S. (**2017**). *Invariant Measurement with Raters and Rating Scales: Rasch Models for Rater-Mediated Assessments*. Routledge.

51. Abd-El-Fattah, S. M. (**2015**). Rasch rating scale analysis of the Arabic version of the physical activity self-efficacy scale for adolescents: A social cognitive perspective. *Psychology*, *6*(16), 2161.
52. Andrich, D. (**2022**). Rating scales and Rasch measurement. *October*, 1–15.
53. Linacre, J. M. (**2002**). Investigating [Title]. *Journal*, 85–106.
54. Linacre, J. M. (**2022**). R Statistics: Survey and review of packages for the estimation of Rasch models. *International Journal of Medical Education*, *13*, 171.
55. Linacre, J. M. (**2021**). *FACETS Rasch Measurement Computer Program* (Version 3.83.6). Winsteps.com.
56. Christensen, R., & Knezek, G. (**2017**). Readiness for integrating mobile learning in the classroom: Challenges, preferences, and possibilities. *Computers in Human Behavior*, *76*, 112–121.
57. Bond, T. G., Yan, Z., & Heene, M. (**2020**). *Applying the Rasch Model: Fundamental Measurement in the Human Sciences*. Routledge. doi:10.4324/9780429030499
58. Fisher, W. P. (**2007**). Rating scale instrument quality criteria. *Rasch Measurement Transactions*, *21*(1), 1095.
59. Taber, K. S. (**2018**). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*, 1273–1296.
60. Park, M., & Liu, X. (**2021**). An investigation of item difficulties in energy aspects across biology, chemistry, environmental science, and physics. *Research in Science Education*, *51*, 43–60.
61. Azizan, N. H., Mahmud, Z., & Rambli, A. (**2020**). Rasch rating scale item estimates using maximum likelihood approach: Effects of sample size on the accuracy and bias of the estimates. *International Journal of Advanced Science and Technology*, *29*(4), 2526–2531.
62. Testa, I., et al. (**2020**). Validation of university entrance tests through Rasch analysis. *Rasch Measurement Applications*, *Quantitative Educational Research*, 99–124.
63. Zwick, R., Thayer, D. T., & Lewis, C. (**1999**). An empirical Bayes approach to Mantel-Haenszel DIF analysis. *Journal of Educational Measurement*, *36*(1), 1–28.