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Development and validation of the critical consciousness scale of environmental issues (CCS-EI): A RASCH model analysis

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ABSTRACT

The present study aimed to develop and validate the Indonesian-language version of the Critical Consciousness Scale of Environmental Issues (CCS-EI), specifically for higher education contexts. Employing Rasch analysis, the study rigorously examines the instrument's reliability and validity through item fit statistics, rating scale functionality, and differential item functioning. The CCS-EI is designed to measure students' critical consciousness in environmental contexts, encompassing dimensions of critical reflection, critical motivation, and critical action. A diverse sample of 579 (male 87%; female 13%) participants from various university in Indonesia completed a 34-item of the CCS-EI. The sampling technique used is convenience sampling. Data were analysed using the Rasch model analysis, it was performed using the Winsteps version 5.6.1.0 software. The results of the Rasch analysis indicated that the reliability of the instrument was excellent (a = 0.91), item quality was excellent (1.00), and person reliability was consistent (0.91). In the validity aspect, all three domains of the CCS-EI exhibited unidimensionality, and a rating scale with four answer choices was deemed appropriate. The study also identifies item difficulty level in each dimension. Furthermore, the CCS-EI showed strong convergent validity, correlating significantly with existing measures of critical reflection, motivation, and action concerning environmental issues. This positions the CCS-EI as a reliable and valid instrument for use in various fields. Its ability to quantify critical consciousness provides valuable insights for designing educational evaluation and shaping policies that promote deeper engagement with environmental sustainability, contributing to both theoretical and practical advancements in the field.

INTRODUCTION

In 1970, Paulo Freire introduced this concept in his seminal work Education for Critical Consciousness, where he highlighted the role of education in fostering consciousness and empowering individuals to act against oppression (Freire, 2021). The concept of critical consciousness represents the ability to recognize and critically analyze societal inequalities, including environmental injustices, and take action to address them (Diemer et al., 2021; Freire, 2021). It encompasses an understanding of social and environmental injustices and a commitment to engaging in actions that challenge inequitable systems and promote ecological sustainability (Anderson et al., 2021; Diemer et al., 2021; Seider et al., 2020). Critical consciousness is a multi-dimensional construct, typically characterized by three components: critical reflection, critical motivation, and critical action (Rapa & Geldhof, 2020; Seider et al., 2020). Critical reflection involves the ability to analyze unjust social conditions and environmental degradation, while critical motivation refers to the drive to pursue social equity and environmental sustainability, and critical action denotes behaviors aimed at effecting social and environmental change (Autin et al., 2022; Christens et al., 2016). Concurrently, critical action represents behaviors that support social change, address social inequalities, and promote sustainable environmental practices through individual and collective action to protect and preserve natural resources (Diemer et al., 2016, 2022; Rapa & Geldhof, 2020).

In the context of the global environmental crisis, the importance of fostering critical consciousness concerning environmental issues cannot be overstated (Diemer et al., 2021; Seider et al., 2020). As environmental degradation continues to escalate, understanding how individuals, particularly students, develop critical consciousness and take proactive steps toward environmental sustainability is crucial. However, despite the increasing emphasis on critical consciousness in education and social justice, there remains a notable gap in tools designed to assess this construct specifically in relation to environmental issues. Existing scales, such as the Critical Consciousness Inventory (CCI) (Thomas et al., 2014), the Transformative Consciousness of Oppression and Privilege (TCOAP) Scale (Maker Castro et al., 2022), and the Critical Consciousness Scale (CCS) (Diemer et al., 2017), primarily focus on social justice and political dynamics, neglecting the environmental dimension of critical consciousness. This oversight limits our ability to comprehensively understand how individuals perceive and engage in environmental challenges.

Several scales developed in previous studies have contributed to the measurement of critical consciousness, each focusing on different aspects of societal inequities. For example, the Critical Consciousness Inventory (CCI) uses the Guttman scaling model to categorize individuals based on their level of critical consciousness development. Similarly, the Transformative Consciousness of Oppression and Privilege (TCOAP) Scale assesses cognition within a social-ecological framework while addressing social desirability bias. Other notable scales include the Critical Consciousness Scale (CCS), the Critical Consciousness Scale—Short (CCS-S) (Rapa et al., 2020), the Anti-Racism Action Scale (ARAS) (Aldana et al., 2019), the Black Community Activism Orientation Scale (BCAOS) (Hope et al., 2019), the Consciousness of Privilege and Oppression Scale–2 (APOS–2), which is a reliable and valid measure of consciousness of privilege and oppression (McClellan et al., 2019), the CCS with a three-factor structure, which included critical reflection, political efficacy, and critical action (Singh et al., 2020), the Teacher Attitudes to Discrimination in Language Education Scale (TADLES), which consists of three factors: critical reflection, political efficacy, and critical action (Leal, 2021), the Asian American Racial Identity Ideological Values (AARIIV) consists of 27-items across three subscales: unity, interracial solidarity, and transnational critical consciousness (Yoo et al., 2021). Additionally, Chan expanded this field by adapting the CCS to the context of Chinese culture, demonstrating the scale's versatility across different socio-cultural environments (Chan, 2022). While these instruments provide valuable insights into social justice-related consciousness, they lack the specificity required to address environmental issues.

The lack of psychometrically validated instruments designed to assess critical consciousness toward environmental issues represents a significant research gap. Although some studies have sought to adapt existing tools for broader contexts, these efforts often fall short in capturing the unique aspects of environmental consciousness. Furthermore, many of these scales do not employ robust statistical methods such as the Rasch Model, which is known for its precision in developing reliable measurement instruments (Andrich, 2017; Wind & Hua, 2022). Previous studies have demonstrated the Rasch Model's superiority over classical test theory approaches, particularly in its ability to provide detailed item-level diagnostics and sample-independent calibration (Adams et al., 2018; Raman et al., 2024; Soeharto et al., 2024). The Rasch Model's probabilistic approach to scaling provides a rigorous framework for validating the psychometric properties of a scale, making it a powerful tool for ensuring measurement accuracy and consistency (Bond et al., 2020; Hughes et al., 2021; Wind & Hua, 2022). To address this gap, the present study introduces the Critical Consciousness Scale of Environmental Issues (CCS-EI), a novel instrument specifically designed to measure individuals' critical consciousness in relation to environmental challenges. Developed using the Rasch Model, the CCS-EI offers a more stringent and theoretically grounded approach to assessing environmental consciousness. This scale provides a valuable resource for researchers, educators, and policymakers seeking to promote critical engagement with environmental issues. By offering a psychometrically sound tool for measuring critical consciousness in the environmental context, this study contributes to the broader effort to foster a more informed and active citizenry in addressing the environmental crisis.

METHODS

Research Design

The research design employed in this study is a quantitative approach that utilizes the Rasch probabilistic measurement model, which is particularly effective for developing and validating measurement instruments (Bond et al., 2020; Soeharto et al., 2024), like the Critical Consciousness Scale of Environmental Issues (CCS-EI). This design choice is well-suited for assessing constructs such as critical consciousness, as quantitative research emphasizes objective measurement and statistical analysis, allowing for reliable and valid conclusions. The Rasch model, a specific application of item response theory (IRT), enhances the robustness of this quantitative approach by providing a sophisticated framework for analyzing the psychometric properties of test items (Wind & Hua, 2022). This model is instrumental in transforming categorical data into interval data, which is crucial for ensuring that the measurement scale accurately reflects the underlying construct being assessed. By applying the Rasch model, we evaluate the reliability and validity of the CCS-EI. Reliability, defined as the degree to which a measurement instrument yields stable and consistent results over time, is a critical psychometric property that the Rasch model helps to establish (Byrd, 2017). The model's specific objectivity ensures that measurements remain invariant across different tests measuring the same construct, thereby reinforcing the reliability of the CCS-EI.

Population and Samples

The participant pool comprised 579 undergraduate students from a range of disciplines at a public higher education institution in Indonesia. This sample was diverse, including variations in age, gender, educational background, race/ethnicity, and field of study, to ensure the scale's applicability across different demographic groups (see Table 1.). The convenience sampling technique was applied for participant selection.

Table 1.
Demographic Profile of Respondents

Demographics	Respondents	Percentage (%)
Gender		
Male	504	87
Female	75	13
Age		
17-20 years	446	77
21-25 years	121	21
> 26 years	12	2
Race/Ethnicity		
Javanese	294	50.8
Lampungese	104	17.9
Sundanese	48	8.3
Batak	42	7.3
Balinese	3	0.6
Chinese	10	1.7
Malay	26	4.3
Padang	8	1.4
Bugis	3	0.6

Demographics	Respondents	Percentage (%)
Buton	12	2.1
Gorontalo	11	1.9
Palembang	9	1.6
Semendo	6	1
Others....	3	0.6
Field of Study		
Natural Sciences (Chemistry, Physics, Biology, Environmental Sciences, etc.)	440	76
General Science (Mathematics, Language Education, Religion Education, Primary Education, ect.)	98	17
Social Sciences (History, Economics, Geography, etc.)	41	7

Instrument

The CCS-IE was specifically designed to assess students' proficiency in critical reflection, critical motivation, and critical action regarding environmental issues within a public higher education institution in Indonesia. This scale is grounded in the framework of critical consciousness theory (CCT), which emphasizes the importance of understanding and addressing social injustices through critical engagement (Diemer et al., 2022; Freire, 2021; Rapa & Geldhof, 2020; Seider et al., 2020). The CCS-IE comprises 34 items distributed across three dimensions: critical reflection (9 items), critical motivation (11 items), and critical action (14 items). Each dimension serves to evaluate different aspects of students' critical consciousness. Critical reflection focuses on students' ability to analyze and understand environmental issues critically, while critical motivation assesses their drive to engage with these issues meaningfully. Finally, critical action measures the tangible steps students take in response to environmental challenges. To facilitate nuanced feedback, the CCS-IE employs a 5-point Likert-type scale, allowing respondents to express their level of agreement with each item, ranging from "strongly disagree" (1) to "strongly agree" (5). This structured response format ensures that each item is answered with a single response, promoting clarity and consistency in data collection. In addition to the core items assessing critical consciousness, the CCS-IE includes five demographic questions that capture essential background information about the respondents. These questions cover age, gender, race/ethnicity, and field of study. This demographic data is crucial for analyzing how various factors may influence students' critical consciousness and engagement with environmental issues.

Table 2.

The Critical Consciousness Scale-Environmental Issues (CCS-EI)

Domain	Item	No Item	Code
Critical Reflection (X)	I have identified and analyzed environmental problem affecting human populations at local, national, and global scales.	1	X1
	I diligently engage in the exploration of diverse perspective pertaining to environmental issues prior to drawing conclusions.	2	X2
	I possess the capability to critically analyse the underlying assumptions and fundamental causes of various environmental problems.	3	X3
	I have the capacity to conduct a thorough analysis of the long-term systemic impacts associated with each environmental issue.	4	X4
	I possess the capability to critically evaluate the accuracy of information pertaining to environmental issues, ensuring verification through credible and authoritative sources prior to acceptance.	5	X5
	I possess the ability to generate creative and innovative solutions addressing environmental challenges impacting human lives.	6	X6
	I acknowledge that my comprehension of environmental issues is shaped by prevailing social values, my educational background, and the academic learning experiences I have encountered on campus.	7	X7

Domain	Item	No Item	Code
	I frequently reflect on the potential contributions of my lifestyle to environmental issues.	8	X8
	I recognize that environmental challenges stem from a complex interplay of social, economic, and political factors.	9	X9
Critical Motivation (Y)	I possess a keen interest in deepening my understanding of environmental issues.	10	Y1
	I am confident in my ability to devise diverse and innovative approaches to address environmental challenges.	11	Y2
	I am strongly motivated to engage in initiatives that promote environmental sustainability.	12	Y3
	I feel a strong sense of responsibility to advocate for environmental issues within my community and society.	13	Y4
	I maintain a keen interest in keeping abreast of the latest advancements and developments in environmental policy.	14	Y5
	I perceive a personal responsibility to contribute to the resolution of environmental issues.	15	Y6
	I consistently strive to stay informed about the evolving nature of environmental issues within society.	16	Y7
	I am deeply committed to identifying innovative approaches for addressing environmental challenges.	17	Y8
	I derive satisfaction from collaborating to identify solutions to environmental issues.	18	Y9
	I am highly motivated to engage in discussions regarding environmental issues.	19	Y10
	I am dedicated to modifying my personal behaviour to minimize my environmental footprint.	20	Y11
Critical Action (Z)	I frequently engage in critical inquiry regarding the causes and potential solutions to environmental issues.	21	Z1
	I am actively engaged in environmental conservation efforts, including activities such as reforestation and tree planting.	22	Z2
	I participate in demonstrations and actions advocating for environmental causes.	23	Z3
	I consistently practice waste reduction, reuse, and recycling as part of my routine.	24	Z4
	I organize and participate in workshops focused on sustainability and environmental issues.	25	Z5
	I regularly contribute ideas and insights in the planning and execution of environmentally focused activities.	26	Z6
	I utilize social media platforms to raise consciousness about environmental issues.	27	Z7
	I integrate eco-friendly practices into my daily life.	28	Z8
	I promote discussions on environmental matters within my social networks.	29	Z9
	I actively campaign for environmental problem-solving initiatives through various digital and social media platforms.	30	Z10
	I frequently involve myself in initiatives addressing environmental challenges.	31	Z11
	I engage in research and publish articles on environmental problem-solving through various digital platforms and social media.	32	Z12
	I have participated in educational courses or training related to environmental issues.	33	Z13
	I endorse and support products and companies that adhere to sustainable practices.	34	Z14

Procedure

The scale development process for the CCS-EI scale consists of four main stages, beginning with item development. In this initial phase, the research team conducted a comprehensive literature review on critical consciousness and environmental issues, alongside consultations with experts in relevant fields. This rigorous process culminated in the creation of 34-items designed to measure three dimensions: critical reflection, critical motivation, and critical action. The second stage involved data collection, where the CCS-EI scale was tested on 579 participants from diverse backgrounds to ensure its applicability across various social contexts. This data collection was executed through an online survey, utilizing platforms Google Forms for their accessibility and efficiency. The design of the questionnaire was crucial, focusing on clarity and ease of understanding to maximize response accuracy. Ethical considerations were paramount; prior to distribution, ethical approval was obtained, and participants were informed about the study's purpose, their rights, and the confidentiality of their responses. In the third stage, data analysis was performed using the Rasch model, which is well-regarded for assessing the psychometric properties of measurement tools. The Rasch model's application is particularly beneficial in ensuring that the scale accurately measures the intended constructs, thereby enhancing its validity and reliability. The final stage of the process focused on validation and testing of convergent validity. The CCS-EI scale was compared against established scales, such as the Critical Consciousness Scale, to measure its convergent validity. This comparison is essential for confirming that the new scale effectively captures similar constructs as those measured by existing tools, thereby reinforcing its credibility and utility in research.

Data Analysis Techniques

The application of the Rasch measurement model, particularly through the WINSTEPS version 5.6.1.0 software, plays a crucial role in evaluating the validity and reliability of the CCS-EI instrument. This software facilitates the calibration of item difficulties and person abilities, transforming raw ordinal data, such as Likert-type responses, into logit units. This transformation is essential as it allows for a more nuanced assessment of the data, converting frequency responses into probabilities that can be analyzed mathematically using the logarithm function (Andrich, 2017; Bond et al., 2020; Wind & Hua, 2022). In this study, item measure analysis is conducted to identify which items are most challenging and which are easiest for respondents, thereby providing insights into the instrument's effectiveness. The analysis also categorizes items into fit and misfit based on item fit statistics, which are critical for evaluating the psychometric properties of the CCS-EI. The reliability indices reported in logit measures serve as indicators of the overall quality of the CCS-EI, reflecting its ability to accurately capture variations in respondent performance. The Rasch model's emphasis on the invariance of item parameters across different samples enhances the credibility of the assessment, ensuring that the results are not biased by the specific group of respondents. Moreover, the Rasch model's application in educational assessments is particularly beneficial, as it ensures that test items are finely calibrated to measure students' abilities accurately. This precise calibration is fundamental in developing high-quality assessments that can reliably capture variations in student performance, thereby supporting educational outcomes.

The quality of the CCS-EI is assessed through several evaluation criteria, including item fit, empirical validity, difficulty level, reliability index, and the distribution of respondents' abilities. The Rasch analysis serves as a foundational method for evaluating these criteria, particularly using the INFIT MNSQ and OUTFIT ZSTD values, which are critical for determining item compatibility and empirical validity, respectively (Hughes et al., 2021). The INFIT MNSQ value indicates how well each item aligns with the Rasch model assumptions. Items are categorized based on their INFIT values, where values greater than 1.33 are deemed irrelevant, values between 0.77 and 1.33 are considered relevant, and values below 0.77 are again classified as irrelevant (Hughes et al., 2021). In terms of empirical validity, the OUTFIT ZSTD value is employed to assess how accurately the instrument measures respondents' abilities. An item is considered valid if its OUTFIT ZSTD value is less than or equal to 2.00, while values exceeding this threshold indicate invalidity (Soeharto et al., 2024). The reliability index is categorized into several levels, with values above 0.94 classified as ideal, and those below 0.67 as weak. The JMLE value is utilized to determine the difficulty level of each test item, providing insights into how challenging each item is for respondents (Soeharto et al., 2024). Additionally, the person mean ability is assessed based on established criteria, which further informs the overall evaluation of the instrument's effectiveness in measuring work ability (Soeharto et al., 2024).

Table 3.
Item fit criteria

INFIT MNSQ Value	Category
$x > 1.33$	Irrelevant
$0.77 \leq x \leq 1.33$	Relevant
$x < 0.77$	Irrelevant

Table 4.
Person and item reliability criteria

Reliability value	Category
$r > 0.94$	Ideal
$0.91 \leq r \leq 0.94$	Excellent
$0.81 \leq r \leq 0.90$	Good
$0.67 \leq r \leq 0.80$	Medium
$r < 0.67$	Weak

Table 5.
Criteria for item difficulty level

JMLE measure	Category
$b > 2$	Very difficult
$1 < b \leq 2$	Difficult
$-1 < b \leq 1$	Medium
$-2 < b \leq -1$	Easy
$b \leq -2$	Very easy

Table 6.
Classification of person ability

Persons' average estimation	Category
$p > 1.0$	High ability
$-1 \leq p \leq 1$	Medium ability
$b < -1$	Low ability

RESULTS AND DISCUSSION

The following section provides a comprehensive analysis of the results derived from the Rasch model, highlighting critical metrics that reflect the instrument's validity and reliability. Table 7 presents a comprehensive summary of the psychometric properties of the CCS-EI as analyzed through the Rasch model. This table provides in-depth insights into essential metrics, including item and person measures, reliability indices, and fit statistics, which collectively serve as critical indicators of the instrument's effectiveness and robustness in assessing critical consciousness.

Table 7.
Statistical Summary Based on Rasch Parameters

Psychometrics Attribute	Person	Item
N	579	34
Mean measure	116.2	1980
SD	15.6	269.7
SE	0.03	0.13
Mean Outfit ZSTD	-0.48	0.15
Mean Outfit MNSQ	1.03	1.04
Separation	2.80	13.87
Reliability	0.89	0.99
Cronbach's Alpha	0.91	1.00

The person measure (N = 579) and item count (N = 34) indicate the scope of respondents and items involved in the analysis. The mean measure values for persons (116.2) and items (1980) offer a central tendency perspective, suggesting that, on average, the difficulty level of the items aligns well with the respondents' ability level, indicating appropriate targeting of the instrument. The standard deviation (SD) values—15.6 for persons and 269.7 for items—demonstrate variability within the sample, with a broader spread in item difficulty compared to respondent abilities. This suggests that the CCS-EI includes items that span a wide range of difficulty levels, allowing for nuanced measurement across varying levels of critical consciousness. The standard error (SE) values, 0.03 for persons and 0.13 for items, are relatively low, signifying a high degree of precision in the measurement estimates. Low SE values indicate that both person abilities and item difficulties are estimated with minimal error, which enhances the reliability and stability of the findings.

Analysis of item fit and empirical validity

The assessment of item fit, and empirical validity constitutes a fundamental component in evaluating the quality and effectiveness of test items within the CCS-EI scale. Item fit analysis examines the extent to which individual items align with Rasch measurement model expectations, demonstrating how these items function in measuring the intended construct across varying levels of respondent abilities. Adequate item fit ensures that each item contributes substantively to the overall measurement objectives while minimizing measurement bias and error. Empirical validity, on the other hand, provides insights into the accuracy of the items in capturing the trait they aim to measure. Through metrics such as INFIT Mean Square (MNSQ) and OUTFIT Z-standardized (ZSTD) values, this analysis examines whether items perform consistently across a diverse range of respondents and whether their empirical responses match the theoretical expectations set by the Rasch model. Items that meet the fit criteria are deemed reliable and valid for inclusion.

Table 8.
Item Measure

Entry Number	Total Score	Total Count	JMLE Measure	Model S.E.	Infit		Outfit		PTMA		Exact	Match	Item
					MNSQ	ZSTD	MNSQ	ZSTD	CORR.	EXP	OBS%	EXP%	
33	1471	579	1.34	.05	1.24	1.16	1.36	1.90	.55	.52	36.2	43.8	Z13
31	1562	579	1.12	.05	1.09	1.62	1.14	1.47	.50	.52	40.1	44.6	Z11
26	1618	579	.98	.05	.92	-1.42	.95	-.95	.58	.52	43.8	45.0	Z6
25	1626	579	.96	.05	.95	-.85	.97	-.53	.55	.52	44.1	45.0	Z5
30	1635	579	.93	.05	.95	-.96	.98	-.29	.55	.52	48.6	45.1	Z10
29	1643	579	.91	.05	.92	-1.50	.93	-1.20	.59	.52	44.5	45.1	Z9
23	1654	579	.89	.05	1.00	.10	1.01	.22	.59	.52	42.6	45.3	Z3
32	1665	579	.86	.05	1.00	.02	1.01	.24	.58	.52	43.1	45.3	Z12
22	1746	579	.65	.05	1.14	1.38	1.15	1.55	.59	.51	46.5	45.9	Z2
27	1748	579	.65	.05	1.11	1.84	1.11	1.95	.58	.51	48.8	45.9	Z7
21	1776	579	.58	.05	1.10	1.77	1.12	1.06	.57	.51	49.0	46.1	Z1
24	1809	579	.49	.05	1.29	1.64	1.30	1.78	.59	.51	44.1	46.2	Z4
28	1823	579	.45	.05	1.33	1.28	1.34	1.44	.51	.51	42.6	46.3	Z8
34	1828	579	.44	.05	1.74	1.90	1.77	1.90	.54	.51	36.6	46.3	Z14
4	1920	579	.20	.05	.87	-1.33	.89	-1.03	.53	.50	54.2	46.6	X4
3	1979	579	.04	.05	.85	-1.65	.85	-1.64	.51	.50	50.3	46.7	X3
2	2010	579	-.05	.05	.99	-.11	1.00	.02	.52	.50	50.9	46.9	X2
6	2057	579	-.18	.05	.80	-1.76	.80	-1.74	.56	.69	54.8	47.1	X6
17	2091	579	-.27	.05	.70	-1.81	.71	-1.69	.63	.69	57.4	47.4	Y8
11	2117	579	-.35	.05	.79	-1.90	.80	-1.81	.56	.59	57.3	47.6	Y2
5	2158	579	-.47	.05	1.03	.49	1.03	.53	.52	.58	51.4	47.8	X5
13	2186	579	-.55	.05	.91	-1.56	.97	-.45	.57	.58	57.8	48.0	Y4
8	2213	579	-.63	.06	.89	-1.90	.99	-.10	.52	.58	59.2	48.2	X8
16	2213	579	-.63	.06	.79	-2.02	.77	-1.29	.58	.58	58.8	48.2	Y7
15	2232	579	-.69	.06	.90	-1.74	.91	-1.64	.58	.57	52.8	48.4	Y6
7	2240	579	-.72	.06	1.12	1.97	1.25	1. 50	.51	.57	51.4	48.6	X7
19	2249	579	-.74	.06	.79	-1.05	.77	-1.34	.62	.57	54.5	48.7	Y10
18	2251	579	-.75	.06	.80	-1.75	.80	-1.76	.59	.57	51.4	48.7	Y9
14	2269	579	-.81	.06	.77	-1.31	.78	-1.20	.60	.57	55.4	48.9	Y5
9	2288	579	-.87	.06	.99	-.12	1.04	.76	.50	.57	49.9	49.0	X9
1	2294	579	-.89	.06	1.43	1.66	2.08	1.90	.50	.56	50.9	49.0	X1
10	2300	579	-.91	.06	.87	-1.40	.84	-1.85	.60	.56	50.7	49.2	Y1
12	2317	579	-.96	.06	.80	-1.80	.78	-1.07	.61	.56	50.0	49.4	Y3
20	2332	579	-1.01	.06	.97	-.50	1.05	.92	.54	.56	49.1	49.7	Y11
MEAN	1988.0	579.0	.00	.05	1.00	-.31	1.04	.15			49.4	47.1	
P.SD	269.7	.0	.74	.00	.21	3.43	.28	3.81			6.0	1.6	

The mean Outfit ZSTD and Mean Square (MNSQ) values further support the scale's validity. A Mean Outfit ZSTD of -0.48 for persons and 0.15 for items, alongside Mean Outfit MNSQ values close to the ideal 1.0 (1.03 for persons and 1.04 for items), indicate a good fit between observed data and the Rasch model. These statistics reveal minimal deviations, demonstrating that the items function as expected across various respondent ability levels and reinforcing the instrument's validity. A minor deviation in person fit suggests that most respondents' responses are consistent with model expectations, though slight variations might occur due to individual differences in response patterns.

The separation index, which reflects the spread of person and item measures, is 2.80 for persons and an exceptionally high 13.87 for items. The person separation index of 2.80 indicates that the scale can distinguish between approximately three levels of respondent ability, signifying a moderate level of discriminative power for identifying varying levels of critical consciousness. The high item separation index of 13.87, on the other hand, suggests a strong capacity to categorize items across a broad difficulty spectrum, indicating that the CCS-EI includes items ranging from easy to very challenging. Such a high separation value for items underscores the instrument's effectiveness in assessing respondents across a wide range of critical consciousness levels, from foundational to advanced understanding of environmental issues.

Table 9.
Empirical validity of the item

Dimension	Number of items	OUTFIT ZSTD value	Category
Critical reflection	X1 (1)	1.9	Valid
	X2 (2)	0.02	Valid
	X3 (3)	-1.64	Valid
	X4 (4)	-1.03	Valid
	X5 (5)	0.53	Valid
	X6 (6)	-1.74	Valid
	X7 (7)	1.50	Valid
	X8 (8)	-0.1	Valid
	X9 (9)	0.76	Valid
Critical motivation	Y1 (10)	-1.85	Valid
	Y2 (11)	-1.81	Valid
	Y3 (12)	-1.07	Valid
	Y4 (13)	-0.45	Valid
	Y5 (14)	-1.2	Valid
	Y6 (15)	-1.64	Valid
	Y7 (16)	-1.29	Valid
	Y8 (17)	-1.69	Valid
	Y9 (18)	-1.76	Valid
	Y10 (19)	-1.34	Valid
	Y11 (20)	0.92	Valid
Critical action	Z1 (21)	1.06	Valid
	Z2 (22)	1.55	Valid
	Z3 (23)	0.22	Valid
	Z4 (24)	1.78	Valid
	Z5 (25)	-0.53	Valid
	Z6 (26)	-0.95	Valid
	Z7 (27)	1.95	Valid
	Z8 (28)	1.44	Valid
	Z9 (29)	-1.2	Valid
	Z10 (30)	-0.29	Valid
	Z11 (31)	1.47	Valid
	Z12 (32)	0.24	Valid
	Z13 (33)	1.9	Valid
	Z14 (34)	1.9	Valid

The ZSTD values for outfit provide further confirmation of fit, with all items having ZSTD values within the -2 to +2 range, indicating acceptable fit for most items. Higher ZSTD values (e.g., Item X1 with an outfit ZSTD of 1.90) suggest that this item might be more prone to measurement error or unexpected responses, potentially due to item difficulty or wording issues. Negative ZSTD values, such as for Items Y8 and Y2, indicate stronger fit than expected but may imply redundancy if too consistent across respondents (Fischer et al., 2021). PTMA values for the items range from .50 to .63, which are moderately high correlations. This suggests that most items are positively correlated with the overall scale, meaning they contribute to measuring critical consciousness on environmental issues. Higher PTMA values (e.g., Item Y8 at 0.63) indicate that these items strongly align with the latent trait being measured. The observed match percentages for items vary, with most items aligning reasonably well with the expected model, typically ranging from about 40% to 60%. For example, Item Y8 shows an observed exact match of 57.4%, compared to an expected 47.4%. Higher-than-expected exact matches imply that respondents' answers closely matched model expectations, reinforcing the item's fit. Items with observed match percentages significantly lower than expected (e.g., Item Z13 with 36.2% observed vs. 43.8% expected) may require revision as they deviate more from the model, suggesting either misalignment with the latent construct or need for content clarity.

Analysis of item reliability

The reliability indices further underscore the scale's psychometric soundness, with a person reliability coefficient of 0.89 (good) and item reliability of 0.99 (excellent), both demonstrating high measurement consistency. These values reflect a minimal margin of measurement error and confirm the scale's internal consistency, which is essential for capturing critical consciousness as a cohesive construct (Kumar, 2023; Raman et al., 2024; Soeharto et al., 2024). Additionally, the scale's Cronbach's alpha values confirm strong internal reliability across items, enhancing confidence in its consistent performance. To assess the scale's validity, item and person fit were analyzed using MNSQ infit and outfit statistics (Suchishrava Dubey et al., 2023). Results indicated that both items and participants met the fit validity criteria, demonstrating that the observed data aligned well with the theoretical model. Given the large sample size, z-standardized infit and outfit (ZSTD) values were excluded as fit criteria, following best practices for extensive datasets (Azizan et al., 2020). The high separation indices for items (13.87 logits) and persons (2.80 logits) indicate the scale's ability to distinctly categorize respondents by ability and items by difficulty, thereby affirming its robust construct validity.

The scale exhibited an optimal model-data fit, with mean INFIT and OUTFIT MNSQ values of 1.04 and 1.03, respectively, closely approximating the ideal threshold of 1.0. This close alignment between expected and observed data underscores the scale's precision in measuring the intended construct without significant bias (Liou et al., 2022). The diversity in item difficulty levels, ranging from -1.01 to 1.34 logits, along with item-total correlations (PTMA values between 0.31 and 0.63), further highlights the scale's capacity to capture a spectrum of critical consciousness levels, from fundamental to advanced (Sulaiman et al., 2022). Therefore, the CCS-EI demonstrates itself as a precise and reliable instrument for assessing critical consciousness, with a 49.4% match rate between observed and expected responses, validating its application across diverse educational contexts (Kondratenko et al., 2024). The scale effectively captures varying levels of critical consciousness, offering a comprehensive framework for evaluating critical reflection, motivation, and action within environmental issues across higher education context.

Analysis of item difficulty

Item difficulty refers to the level of challenge each item presents to respondents, which is crucial for determining whether the instrument can adequately differentiate between individuals with varying levels of the measured trait. The item difficulty level can be effectively justified through the analysis of Joint Maximum Likelihood Estimation (JMLE) measure values (Adams et al., 2018). The JMLE measure values serve as a direct indicator of this difficulty, reinforcing the notion that items with higher JMLE values are indeed more challenging for examinees.

Table 10.
Difficulty level of item based on JMLE measure

Dimension	Number of items	*B*	Category
Critical reflection (X)	X1 (1)	-0.89	Medium
	X2 (2)	-0.05	Medium
	X3 (3)	0.04	Medium
	X4 (4)	0.2	Medium
	X5 (5)	-0.47	Medium
	X6 (6)	-0.18	Medium
	X7 (7)	-0.72	Medium
	X8 (8)	-0.63	Medium
	X9 (9)	-0.87	Medium
Critical motivation (Y)	Y1 (10)	-0.91	Medium
	Y2 (11)	-0.35	Medium

Dimension	Number of items	*B*	Category
	Y3 (12)	-0.96	Medium
	Y4 (13)	-0.55	Medium
	Y5 (14)	-0.81	Medium
	Y6 (15)	-0.69	Medium
	Y7 (16)	-0.63	Medium
	Y8 (17)	-0.27	Medium
	Y9 (18)	-0.75	Medium
	Y10 (19)	-0.74	Medium
	Y11 (20)	-1.01	Easy
Critical action (Z)	Z1 (21)	0.58	Medium
	Z2 (22)	0.65	Medium
	Z3 (23)	0.89	Medium
	Z4 (24)	0.49	Medium
	Z5 (25)	0.96	Medium
	Z6 (26)	0.98	Medium
	Z7 (27)	0.65	Medium
	Z8 (28)	0.45	Medium
	Z9 (29)	0.91	Medium
	Z10 (30)	0.93	Medium
	Z11 (31)	1.12	Difficult
	Z12 (32)	0.86	Medium
	Z13 (33)	1.34	Difficult
	Z14 (34)	0.44	Medium

Based on Table 10, the distribution of items across different difficulty levels allows for a well-rounded assessment of the dimensions within the CCS-EI. The Medium level dominance across all dimensions indicates that the instrument is well-suited for average ability levels, where respondents typically demonstrate basic understanding of environmental issues but may not consistently engage in advanced critical analysis or action. The presence of Easy items within critical motivation helps identify respondents who are beginning to develop environmental awareness and show initial interest in environmental issues, distinguishing them from those who have not yet developed basic environmental consciousness. Meanwhile, the Difficult items within Critical Action effectively differentiate between respondents who merely possess knowledge and those who actively engage in complex environmental initiatives, such as organizing collective actions or implementing systematic environmental solutions. This strategic balance of item difficulties ensures that the instrument can accurately distinguish between novice respondents (who can only respond to easy items), intermediate respondents (who can handle medium-difficulty items), and advanced respondents (who can successfully engage with the most challenging items), thereby providing a more nuanced understanding of respondents' developmental stages in environmental critical consciousness.

Distribution of students ‘abilities (Wright map analysis)

The Wright Map, or Person-Item Map, displayed here provides a comprehensive view of the alignment between student abilities and item difficulties along the same measurement scale. The map uses a vertical scale of "Measure," with higher levels indicating greater levels of the measured construct—in this case, critical consciousness. The map is divided into two primary columns: on the left are the respondents (represented by "#" for groups and "." for individuals) and on the right are the items, labelled as X, Y, and Z followed by numbers.

Most respondents fall between measure levels 0 and 2, with the highest concentration around measure level 1. This clustering indicates that most students exhibit a moderate level of critical consciousness, aligning with items in the middle range of difficulty. There are fewer respondents at the extreme ends of the scale, suggesting that only a small proportion of students have very high or very low critical consciousness levels. This distribution reflects a bell curve, indicating a typical range of ability levels within the population.

The items span a range of difficulty levels, from approximately -1 to 3 on the measure scale. Items labelled with higher values, such as Z13 and Z11 (around measure level 2), are among the most challenging, requiring a higher level of critical consciousness to respond favourably. Conversely, items at lower measure levels, such as Y11 and Y3 (below 0), are easier, making them more accessible to respondents with lower levels of critical consciousness. The clustering of respondents around measure level 1 suggests that the test items are well-targeted for this sample population, as most items align closely with most students' abilities. The distribution of items above and below the respondents' cluster ensures that the scale can effectively differentiate students with both lower and higher critical consciousness levels, providing a balanced assessment. However, there are fewer items at the higher difficulty levels (above measure level 3), indicating that the scale may have limited capacity to differentiate among students with very high levels of critical consciousness. Adding more challenging items could improve the instrument's ability to measure the full spectrum of high ability levels. The markers "S," "M," and "T" correspond to the 25th, 50th (median), and 75th percentiles, respectively, indicating the spread of respondent abilities. The concentration below the median line (M) suggests that most respondents find the test items moderately challenging, and only a smaller subset has high enough ability to reach the more challenging items at the top of the map.

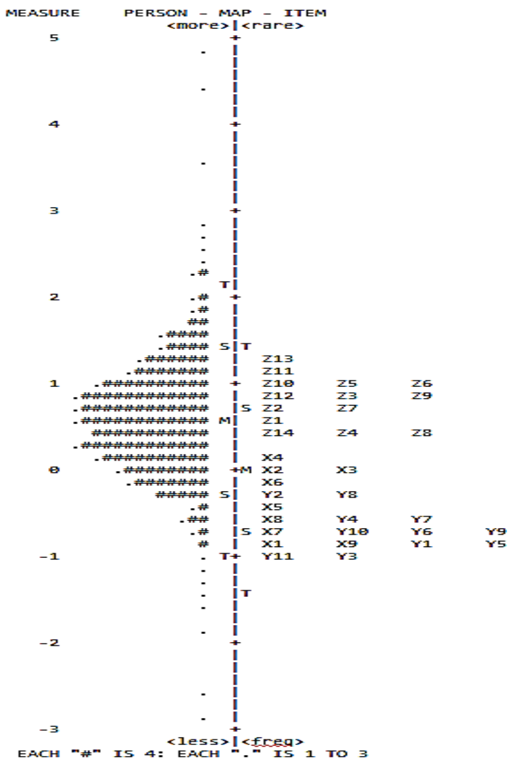

Figure 1. Wright map analysis

Based on the person-item map (Wright Map) shown in Figure 1, the analysis reveals two key distributions. On the left side, the distribution of person abilities (respondents), represented by #/. symbols, forms a roughly normal distribution pattern, suggesting that the sample's response pattern follows an expected normal curve - a desirable characteristic for measurement instruments. On the right side, the item difficulties, represented by numeric values, demonstrate varying levels of complexity. The items are spread across different difficulty levels, with a notable clustering of items in the middle range. However, there are fewer items at the extreme ends (very easy or very difficult), and some noticeable gaps exist in the item difficulty continuum. This distribution pattern indicates that while the instrument effectively measures average ability levels, it may need additional items at both extremes to better assess respondents with particularly high or low abilities, and some intermediate difficulty levels could be filled to provide more precise measurement across the full range of abilities.

Analysis of item characteristic curve (ICC)

The ICC PLOT is a tool for evaluating how well the item performs in differentiating between respondents with varying levels of the underlying trait being measured.

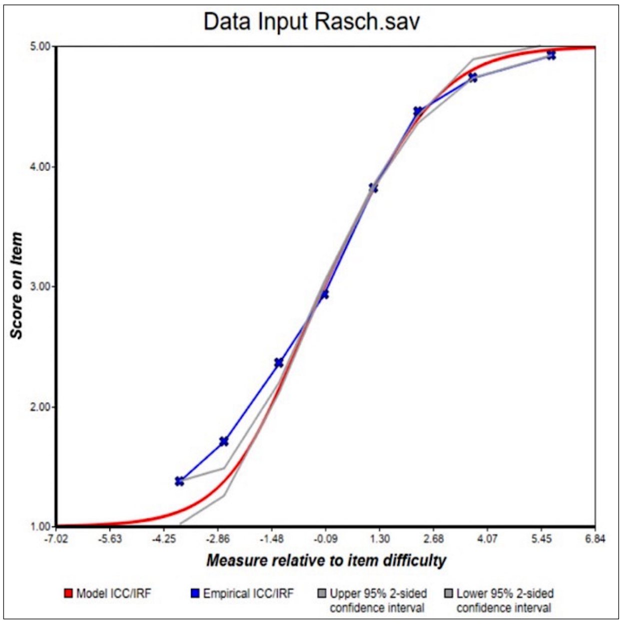

Figure 2. ICC plot analysis

The horizontal axis represents the ability measure relative to item difficulty. Negative values indicate lower levels of the trait, while positive values represent higher levels. The measure range spans from approximately -7 to +6, encompassing a broad range of ability levels in the respondent population. The vertical axis indicates the expected score on the item, ranging from 1 (lowest possible score) to 5 (highest possible score). This axis helps in understanding how the respondents' scores vary based on their ability levels.

The red line represents the theoretical Item Characteristic Curve (ICC) as predicted by the Rasch model. This curve shows the expected score for respondents based on their trait level relative to the item's difficulty. It provides a baseline for how the item should perform according to the Rasch model's assumptions. The blue line shows the empirical Item Characteristic Curve (ICC), based on the actual responses from the data. This line represents observed respondent performance and provides insight into how well the item behaves compared to the model's expectations. When the blue line closely aligns with the red line, it indicates that the item fits well with the Rasch model and accurately reflects the trait being measured. The upper and lower 95% confidence intervals (grey lines) provide a range in which we expect the observed data to fall, given sampling variability. These intervals help assess the precision of the empirical ICC.

Across most of the curve, the empirical (blue) and model (red) ICCs are closely aligned, suggesting that the item fits well with the Rasch model. This alignment indicates that the item performs as expected, differentiating respondents with varying levels of ability consistently. The tight fit within the confidence intervals further supports the reliability of the item, as observed scores generally fall within the expected range. At the lower end of the trait spectrum (around -4 to -2), the blue line slightly deviates above the red line. This deviation suggests that respondents at these lower ability levels scored slightly higher than predicted, indicating that the item may be somewhat easier for these respondents than the model anticipated.

In the moderate range (between -1 and +2), the empirical and model ICCs align very closely, demonstrating that the item functions as expected for respondents with average to moderately high trait levels. This close alignment indicates that the item is effective in distinguishing between respondents within this middle range, as it provides scores that match the predicted values closely. For respondents with higher ability levels (above +2), the blue and red lines are nearly identical, showing that the item maintains its effectiveness at these trait levels. This consistency implies that the item reliably differentiates respondents with high levels of the trait, accurately capturing their ability levels without deviation from the model's predictions.

The ICC plot suggests that this item performs well across a broad range of respondent abilities, showing a strong fit to the Rasch model with only minor deviations at very low trait levels. The alignment between the model-predicted and empirical ICCs indicates that the item is reliable, and functions as expected in measuring critical awareness. Overall, this item is effective in assessing respondents across a wide ability range, though adding or refining items for extreme lower or higher trait levels may enhance precision in capturing the entire spectrum of abilities.

CONCLUSION

This study successfully developed and validated the Critical Consciousness Scale for Environmental Issues (CCS-EI) as a reliable and valid instrument for measuring critical consciousness regarding environmental issues. Using the Rasch model, the CCS-EI demonstrated strong psychometric properties, with high person and item separation indices (2.80 and 13.87, respectively) indicating that the scale can effectively distinguish between different levels of critical consciousness among respondents. The INFIT and OUTFIT statistics further confirmed that most items fit well with the Rasch model, supporting the empirical validity of the instrument. The reliability analysis, which yielded high reliability indices and Cronbach's Alpha values, confirms that the CCS-EI provides consistent measurements across different respondent samples. Additionally, the Wright Map analysis showed that the item difficulty levels are well-aligned with respondent abilities, while the Item Characteristic Curve (ICC) analysis demonstrated that the items function as expected across a range of ability levels. Differential Item Functioning (DIF) analysis revealed varying patterns of environmental critical consciousness across different demographic factors, with female respondents showing higher sensitivity to local environmental issues and urban respondents demonstrating stronger awareness of systemic environmental challenges. These findings have important implications for environmental education, suggesting the need for tailored instructional approaches that address gender-specific perspectives and consider geographical contexts. Educators can utilize these insights to develop targeted interventions that strengthen areas where specific demographic groups show lower levels of critical consciousness. In classroom implementation, the results indicate the importance of incorporating diverse environmental contexts and ensuring inclusive teaching strategies that address the varying levels of environmental awareness across different student populations. Future research may consider adding items at the extreme ends of the difficulty spectrum to further enhance the scale's ability to capture very high and very low levels of critical consciousness, thereby extending its applicability across diverse populations. Moreover, the findings suggest the need for developing differentiated teaching materials and assessment strategies that account for students' varied backgrounds and experiences with environmental issues.

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